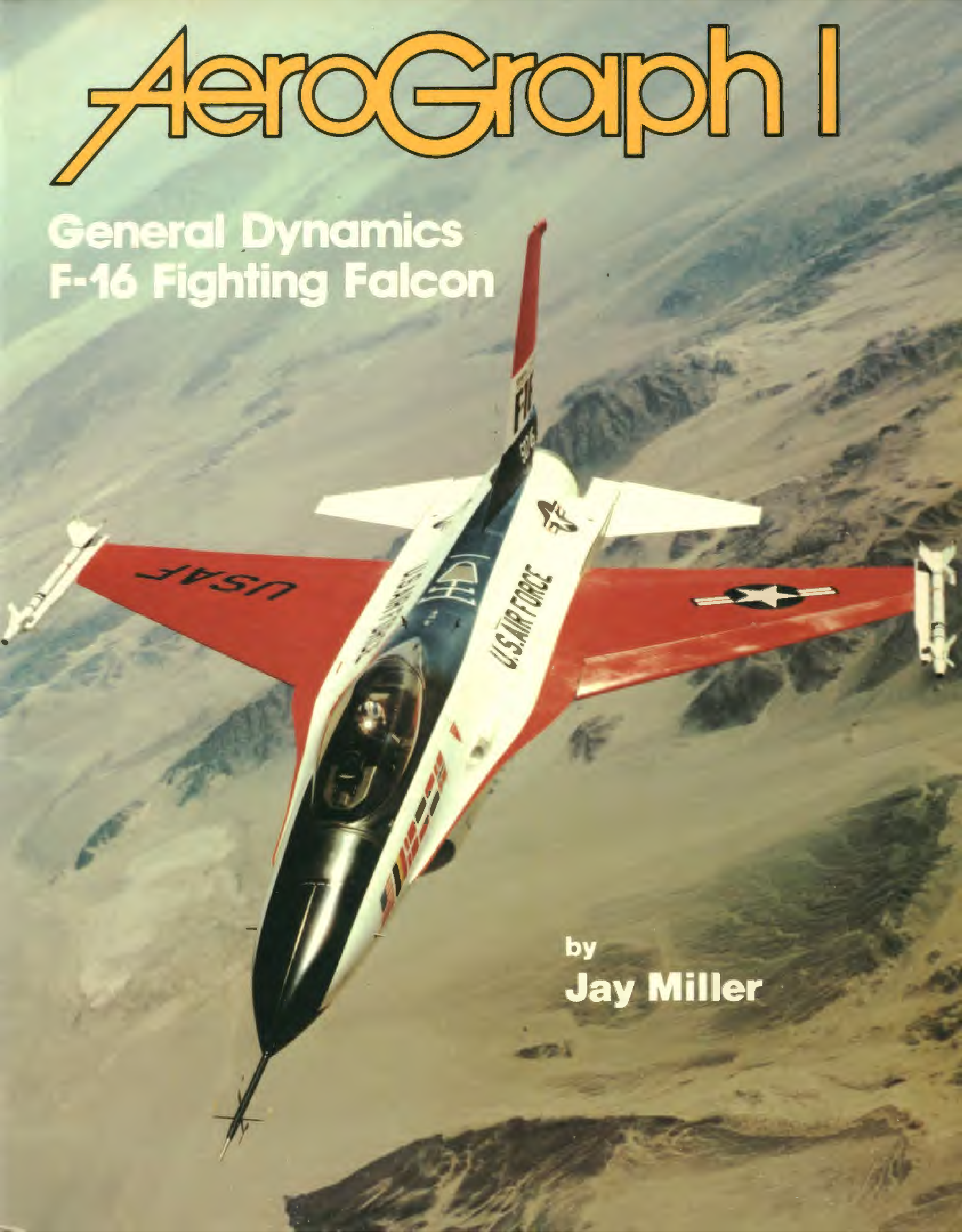
# AeroGraph I

## General Dynamics F-16 Fighting Falcon

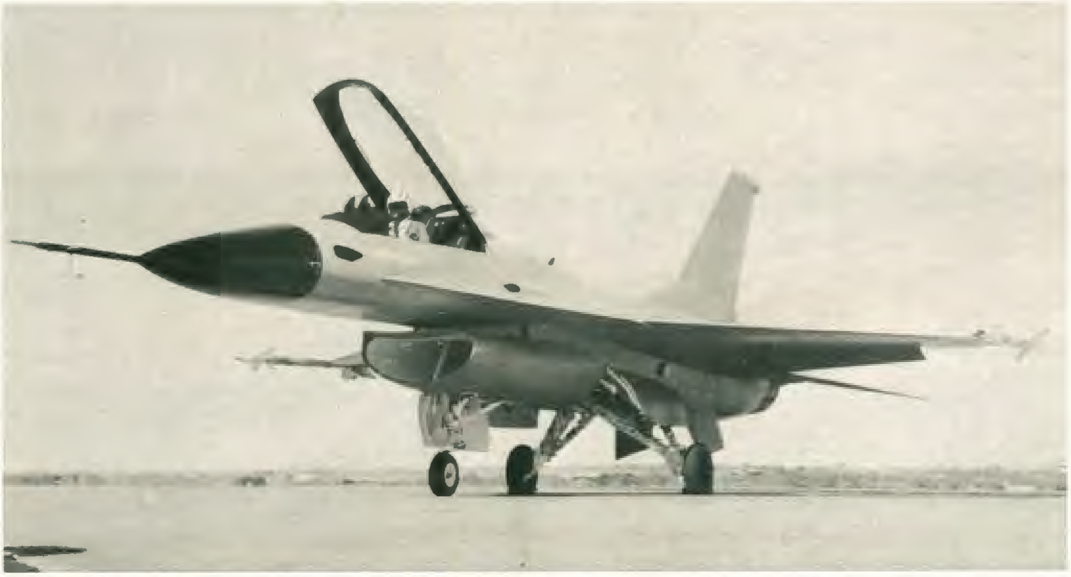
by

**Jay Miller**



# THE GENERAL DYNAMICS F-16 FIGHTING FALCON

## by Jay Miller



*The fourth FSD F-16A, 75-0748, poses on the ramp at General Dynamics Fort Worth, Texas facility shortly after roll-out. General Dynamics*

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*Cover Photo: The first FSD (Full Scale Development) F-16A, 75-0745, poses for General Dynamics photographers during test hop over Edwards AFB, California. Visible on fuselage side, just below cockpit canopy, are flags of the various countries that had ordered the F-16 at the time. Among those represented is that of Iran. General Dynamics*

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THE GENERAL DYNAMICS F-16 FIGHTING FALCON
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*December 8, 1976; the first FSD F-16A, 75-0745, heads skyward from the main Carswell AFB runway on its first flight. Company test pilot Neil Anderson was at the controls. General Dynamics*

AF 60 543

# PREFACE

Fighter technology has at last come full circle. With the birth and operational deployment of the General Dynamics F-16 *Fighting Falcon*, a trend that has threatened the lifeblood of the U.S. Air Force for over three decades has at last been curbed—though (and this must be emphasized) not completely controlled.

This trend, summarized in the word "technocracy", has given birth to what is unquestionably the most complex and sophisticated air combat force in the history of the world. Striving desperately and, in most cases, futilely, for ever more effective fighters, bombers, and other aerial weapons of war, U.S. technologists and bureaucrats (both civil and military) have created a Frankensteinian air force that on paper never fails to work as planned; but once formed into hardware, has a perforated mentality that stops and starts, succeeds and fails, and in general has a mediocre dependability record.

In an effort to overcome this trend toward more and more sophistication and less and less dependability, a small group of dedicated and extraordinarily capable Pentagonians has informally assembled into an aggressive and brilliant team of lightweight fighter proponents known among friends and foes alike as the "Lightweight Fighter Mafia".

Though challenged at every level of the bureaucracy, and outweighed ten to one in the Pentagon power structure, this small team, in the early 1960's, began a quiet but masterfully directed program that would eventually give birth to the F-16. The "Mafia's" efforts while guiding the seed of this surreptitious undertaking through the myriad channels of the Pentagon hierarchy—and all the while protecting it from a veritable army of foes—is a story well worth telling.

AEROGRAPH I, THE GENERAL DYNAMICS F-16 *FIGHTING FALCON*, is that story.

Jay Miller
January 1982

# ACKNOWLEDGEMENTS

The creation of this book has been a rather complex and difficult undertaking—analogous, in some respects to the creation and gestation of its subject. A great number of folks both directly and indirectly related to the F-16 were interviewed, cornered, cajoled, and befriended by the author in an attempt to make this the most complete and thorough history of the subject aircraft yet published. Numerous documents were referenced, thousands of photographs were scanned, and in total, not a stone was left unturned.

As is often the case with a reference book such as this, key people in the respective company's public relations department played a big role in getting the project off dead center. Those folks at General Dynamics Fort Worth Division deserving special mention were Rob Mack, Joe Thornton (particular thanks), and Margaret Gamble. Those at General Dynamics' main office in St. Louis were Fred Bettinger and Ray Forbes.

Other General Dynamics personnel who proved of particular importance include friend and respected photographer Bill Williams, friend and test pilot extraordinaire Phil Oestricher, and noted test pilot Neil Anderson.

Last, but by far, not least in the list of General Dynamics contributors are Harry Hillaker and Lyman Josephs. These extraordinary engineers, who are the acknowledged creators of the F-16, made exemplary contributions in terms of time and information. This book would not have been possible without their input.

On the government side the list must begin with a special thanks to the likes of John Boyd, Pierre Sprey, Everest Riccioni, and Charles Myers, Jr. These men, collectively and respectfully known as the "Lightweight Fighter Mafia", proved to be rich sources of technical and historical information and gave freely of their time and talent.

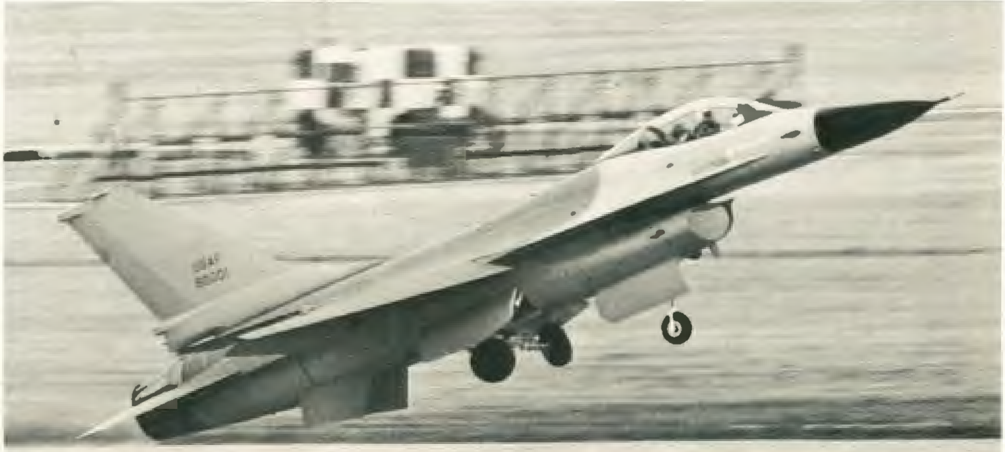
On the Air Force side, thanks must go to Col. Jerauld Gentry (whose semi-definitive history of the lightweight fighter program's tumultuous early days proved to be the informational and textual basis for the first third of this book); Lt. Col. Solander of the Air Force Public Affairs Office; MSgt. John Ogden of the Bergstrom AFB Transient Alert; SMSgt. Bob Jarvis (now retired), Sgt. Gary Smith and Mrs. Evelyn Walsh of the Bergstrom AFB Office of Information; Maj. Bill Campbell of the Air Force Systems Command; Lt. Ed Worley (PAO, MacDill AFB, Florida); Capt. Marc Moore; Capt. John Rogers, and Brig. Gen. George Monahan, Jr. Deputy for the F-16 (F-16 SPO), Aeronautical Systems Division.

Others who made serious contributions include friend and retired director of General Dynamics' enigmatic special projects office, Vinko Dolson; friend and AIL Division, Eaton Corporation's assistant to the president, Richard Dunne; Westinghouse Electric Corporation's Dick Knight and Kent Hutchinson; Stencel Aero Engineering Corporation's H. V. Greene; retired Edwards AFB Historian and friend Ted Bear; Eva Tone Corporation's Dave Schroeder; special friend Robb Satterfield; friend and photographer Fred Harl; Manager of Public Relations for Hughes Aircraft Company, Harold Watkins; McDonnell Douglas Corporation's Lon Nordeen; and friends Donald McGarry; Norm Taylor; Steve Billings; Chris Pocock; Jack Poelstra; MSgt. Al Mongeon; Tim McGovern; John Kerr; Carlos Femat; Lee Bracken; Lon Cooper; Pat O'Bryan; Chuck Davis, and always cooperative banker, Bill Cason, and especially B.IJ—who wishes to remain anonymous but whose contributions, in my opinion, must be acknowledged.

This book is filled with numerous outstanding photographs and not all of them have come from General Dynamics or AEROFAX files. Among the many private contributors were George Cockle and Jim Goodall; the former being both friend and master camera aimer, and the latter being both friend and world's most fanatic SR-71 nut.

Unfortunately, it is likely that several who have contributed have been overlooked. I apologize for this and want to emphasize that the oversight is not intentional.

Finally, I'd like to once again say thanks to the greatest person I know, *my wife*. Her patience, support, and perseverance are marvels of the modern world.

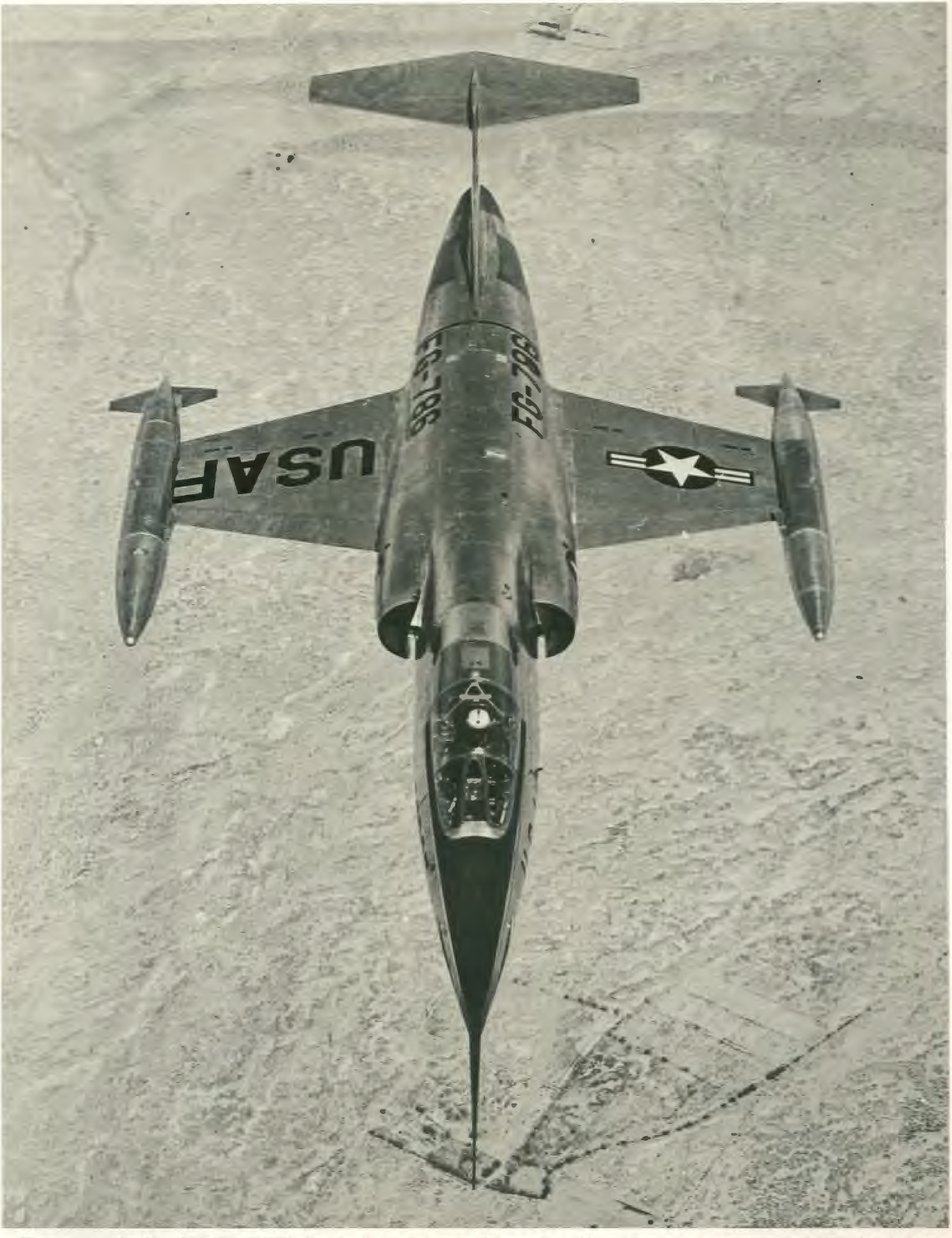


*Right*

*The first production F-16A, 78-0001, takes off on its Air Force delivery flight which occurred in August of 1978. Note gear retraction process caught midway in the sequence. General Dynamics*

*Left*

*A late production F-16A, 80-0543, one of the first to incorporate MSIP modifications scheduled for all forthcoming F-16's, climbs vertically over one of many lakes that dot the Fort Worth, Texas countryside. Note that this airplane also has the new increased-area horizontal stabilators. General Dynamics*



*The prototype Lockheed XF-104, 53-7786, flew for the first time on February 7, 1954. In this photo, taken in April of 1956, the airplane is shown while powered by a 10,000 lb. th. Wright XJ65-W-6 turbojet and with its original unspiked intakes. Lockheed-California*

# CHAPTER I
# BACKGROUND

KISS—*Keep It Simple Stupid*, has long been an unwritten law in the world of aerial combat. Avoid, at all costs, overburdening the pilot's mind with details that hinder; optimize his concentration and remove his distractions; and couple these elements with an exceptionally maneuverable platform and an armament system that works. Do these things—and the ultimate fighter pilot has been created.

Thus it is that for the first time in almost three decades, the Air Force has acquired an air-to-air combat aircraft that at last has broken the ever-spiraling trend toward more complex and more expensive fighters. With the advent and entry into operational service of the F-16, a new chapter in the book of fighter philosophy has at long last been written—and in so doing, has opened the door to revised and improved editions for many years to come.

The conception, gestation, and birth of the F-16 was a long and at times trying experience for the many folks who played key roles in its journey from idea to operational hardware. Among the more prominent names are those of John Boyd, Everest Riccioni, Pierre Sprey, Harry Hillaker, and Charles ("Chuck") Myers. Though from diverse, and at times conflicting backgrounds, each of these men, in the early 1960's, came to believe in one thing—a low cost, high performance fighter was desperately needed by the Air Force (and, in fact, also by the Navy).

In the mid-1960's, the United States was heavily involved in the Viet Nam war. The Air Force, because it had no new tactical fighter or attack aircraft which could be put rapidly into production, had found itself in the predicament of having to procure adaptations of two U.S. Navy aircraft, the McDonnell F-4 *Phantom II*, and the Vought (Ling Temco Vought) A-7 *Corsair II*. (Though the General Dynamics F-111, born in response to the Tactical Fighter Experimental {TFX}contract competition, was in production for the Air Force, numerous problems with this aircraft had raised serious questions concerning both the length of its production program and its utility in the Viet Nam arena. At a later date, {1968}, it did, in fact, suffer an extraordinarily high loss rate during its combat baptism and was withdrawn from Viet Nam after only eight months of service).

Two other U.S.-designed and manufactured tactical fighter-type aircraft were also in production during this mid-1960's period, though their use by the Air Force was considered operationally limited. These aircraft were the Lockheed F-104 *Starfighter* and the Northrop F-5 *Freedom Fighter*.

Approximately 300 F-104A's, F-104B's, F-104C's, and F-104D's had been procured by the Air Force in the late 1950's for point defense interceptor work. Later, the type (in heavier, multi-mission F-104G form) was also sold to a four-nation European consortium (consisting of Germany, Italy, Belgium, and the Netherlands). The success of this consortium paved the way for additional co-production arrangements in Canada and Japan and eventually led to the sale of approximately 2,500 F-104's in some 15 countries.

While acquisition of the F-104 continued unabated throughout much of the rest of the world, the Air Force, in the mid-1960's, began rapid phase-out of the aircraft from its own operational units. At the same time, it agreed to maintain ongoing F-104 flight and maintenance training for foreign air force students (which, in fact, continues to this very day at Luke AFB in Arizona).

The withdrawal of the F-104 from the active Air Force inventory effectively eliminated what was to all intents and purposes the service's only legitimate "lightweight" fighter. At the time, this fact had little if any relevance to the Air Force as the desire for bigger and more complex combat aircraft had already begun to blind the services's hierarchy to the attributes of this proven (but rarely acknowledged) philosophy.

In 1962, as the wheels began to turn leading to the demise of the F-104 as an active Air Force fighter type, the Air Force awarded Northrop a contract to produce the F-5 *Freedom Fighter* (originally known as the N-156). This airplane was a very lightweight (13,000 pound), twin-engine tactical fighter developed in parallel with the Air Force's T-38 *Talon* supersonic jet trainer. The latter had been in service with the Air Force since 1961, and had met with significant success in the training role. Worthy of note is the fact that not long after entering service, the T-38 became the first trainer aircraft ever to claim the jet aircraft world absolute time-to-climb speed records.

In funding the F-5 program, the Department of Defense (DoD) had committed itself to the idea of developing a simple, inexpensive, but reasonably capable fighter which could be provided or sold to countries which could not afford, or lacked the ability to operate, more complex types. The Air Force eventually supervised and participated in the development, testing, and production of the F-5A (and the two-seat F-5B), and approximately 1,100 were delivered to some 15 countries over an eight-year period. As with the F-104, the Air Force provided F-5 support and training to allies even though the F-5 was technically not an active Air Force inventory aircraft (though 12 F-5A's, leased from the Military Assistance Program, were temporarily operated by the Air Force in Viet Nam as the "Skoshi Tiger" test squadron).

Thanks to the successes of their respective programs, both Lockheed and Northrop quickly dveloped support sites and field offices in each of the countries operating their aircraft. Lockheed, in fact, developed a more direct field operation as the F-104 was not only utilized by numerous foreign air forces, it was also produced at six foreign manufacturing sites.

As Northrop and Lockheed began to expand their sales programs and explore the needs of their respective customers, it became more and more apparent to both that there was a vast foreign market for military aircraft, equipment, and related support. Additionally, the two companies concluded that eventually there would be a need in the 1970's and 1980's for follow-on aircraft to replace the F-104's and F-5's then entering service. It was only proper that they should surmise that the foreign foothold they were then developing might prove a key element in future successful sales.

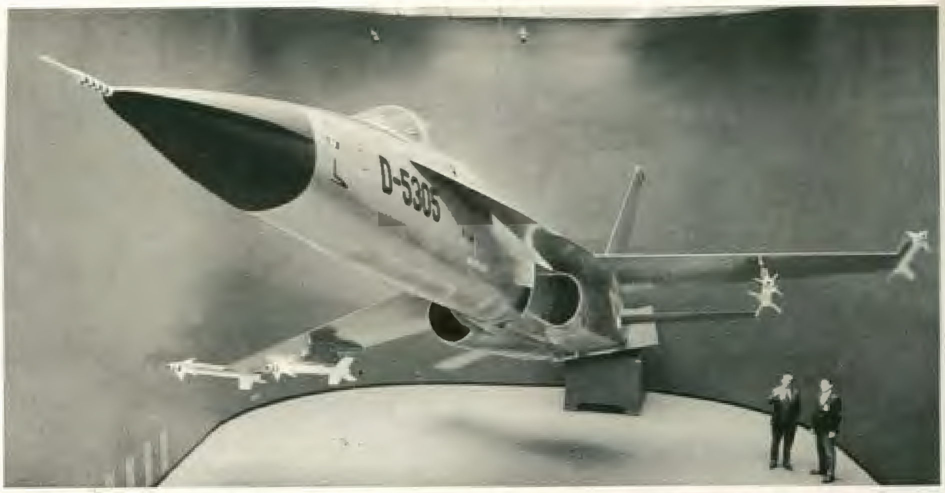
An analysis of potential competition by both Lockheed and Northrop soon led each to the conclusion that a monopoly was not totally out of the question. Indigenous aircraft in the price and performance range encompassed by the F-104 and F-5 were simply non-existent, and the only airplane on the European continent that was considered competitive was the French Dassault *Mirage III*. This aircraft, in fact, was an exceptional performer, but during a head-to-head NATO consortium competition with the F-104, it had come up second best.

Once Lockheed and Northrop concluded that there would definitely be a need for an F-104 and/or F-5 replacement, the two companies began pumping in-house funding into design studies that, it was hoped, would create the winning airplane.

Lockheed's planning, understandably, focused heavily on the existing F-104 market and manufacturing base. The company's goal became the design of a new aircraft with greatly improved performance but with 70 to 80 percent F-104 commonality. Obviously, the company's philosophy was that such an airplane, by retaining proven parts and equipment in order to lower cost, would be especially attractive to those countries already producing and/or operating the F-104.

Lockheed assigned the project to Clarence L. "Kelly" Johnson who, not surprisingly, had played a key role in the F-104's design (and promotion). Johnson worked diligently to create the hybrid airplane Lockheed needed for an F-104 follow-on and following numerous variations to the stock F-104 modification theme, he unveiled his Model CL-985. This airplane was basically a modified F-104 with a slightly more powerful engine, a wing of slightly increased area, and a fuselage with numerous minor modifications and changes. It was claimed to have superior top speed and

*The prototype Northrop N-156F, 59-4987, the first of the F-5 series, banks away from the camera ship during a test hop over Edwards AFB, California in late 1959. This airplane is presently in storage as part of the Pacific Northwest Historical Society collection in Seattle, Washington.* Northrop



***Full-scale mock-up of the definitive Northrop P-530 Cobra configuration. Northrop's YF-17 lightweight fighter prototype was based on the design studies generated for this airplane.***
***Northrop***

maneuvering performance, and most importantly (for unhappy F-104 drivers), much improved landing and takeoff speeds.

In the meantime, Northrop, too, had hopped on the bandwagon and in fact had taken its replacement fighter airplane studies a step beyond those of Lockheed. Though studies for improved and much modified F-5's were conducted, the primary thrust of the Northrop work was to develop a totally new fighter tailored to the force modernization requirements perceived by many NATO countries for the 1970's. As such, it would be competing head to head with any fighter Lockheed threw into the ring.

Northrop's new airplane, when finally unveiled in mock-up form, was the P-530 *Cobra*. It was a totally new and totally fresh approach to fighter design and it incorporated such innovative technologies as high-lift aerodynamics and modern, high-thrust-to-weight-ratio turbofan engines..

The twin-engine P-530 was designed primarily to serve as a multi-purpose air superiority and ground attack fighter and with its relatively light weight and new engines, it was expected to achieve a top speed of approximately Mach 2.

Like Lockheed, Northrop envisioned a multinational co-production effort similar to that enjoyed by the F-104. In order to improve the possibility of this occurring, Northrop elected to engage in some creative marketing strategy of its own. Accordingly, the company proposed that the P-530 be prototyped and produced without dependency on U.S. Government funding. Instead, it would be financed entirely by the participating nations.

The program was basically broken into two distinct phases. One called for a pre-production or development effort to validate the design and flight test several prototypes; and the other called for a production program including full qualification and delivery of combat ready aircraft.

Because the cost burden was designed to be spread across several buyers, Northrop elected to withhold a firm commitment to the program unless orders for 400 or more aircraft could be received, or unless $100-million could be obtained (primarily to fund the preliminary research and construction and flight test of the prototypes).

By this time, both the Lockheed and Northrop programs were moving along at a steady pace and sales efforts in a number of foreign countries were reaching a feverish pitch. In a somewhat unexpected coup by Northrop, the DoD, under pressure from the Office of the Secretary of Defense (OSD), agreed to back the P-530 program and help financially with its promotion and sales. The rationalization for this was the "pressing need for a new fighter" in Europe and the feeling that no other U.S. aircraft had the potential to fill this need quickly and effectively (which, of course, immensely displeased Lockheed with their CL-985). Unfortunately, Northrop was later to prove unable to meet several of the government financial support requirements and the money was used elsewhere.

While Northrop and Lockheed involved themselves in the creation of new fighters to sell to foreign customers, the Air Force, under pressure from the Under Office of the Assistant Secretary of Defense, Systems Analysis (OASD/SA), initiated a new fighter study known as the F-X (for Fighter Experimental) that had the primary objective of bolstering Air Force tactical strength as rapidly and economically as possible. Two aircraft, the Vought A-7 and the Northrop F-5, both already in production, were presented by proponents as being suitable for filling the F-X role.

Following much debate and OSD pressure, the Air Force opted for the A-7 in November of 1965. Although this decision was hailed in some circles as a victory for the ground attack and commonality advocates (the A-7 was used by the Navy and was originally designed to a Navy specification), perhaps more importantly, it established the argument for developing a new, air superiority-oriented Air Force fighter.

Further strengthening this argument was the less than accustomed success being enjoyed by U.S. fighters in combat with Soviet-built MiG fighters over Viet Nam. In 1965, the combat "kill" exchange ratio, at best, was 3.3 to 1, compared to 10 to 1 and better during the Korean War. Subsequently, the exchange ratio decayed to slightly better than 1.5 to 1. Analysis of the problem determined that this decay, to a very large extent, was the result of the shift in emphasis in the 1950's to air-to-air missiles and away from maneuverability. This was underscored by the fact that the two most prominent missiles in use in Viet Nam, the AIM-7 *Sparrow* and the AIM-9 *Sidewinder*, rarely worked according to plan. The former, in fact, had a PK (Prob. of Kill —— a figure acquired by determining how many missiles it takes to destroy an enemy aircraft; usually based on a figure of how many out of any ten rounds fired; a perfect score would be 1.0, a score of one out of ten would be 0.10; the lower the figure the poorer the performance) of approximately .15 in fighter-versus-fighter combat, and the latter had a PK of approximately .20.

Because there was an obvious need, another fighter concept, also referred to as the F-X, was chartered by the Air Staff (the Tactical Air Command, by this time, had been issuing requirements documentation for a new air superiority fighter for about two years). The (new) F-X Concept Formulation Phase was initiated in December of 1965 with the release to the aerospace industry of requests for parametric design studies.

Hundreds of designs now filtered in for evaluation and analysis. Sprouting from these was a proposal by the Air Force Systems Command (AFSC) calling for a multi-purpose fighter weighing approximately 60,000 pounds and having a variable sweep wing. Its similarity to the on-going General Dynamics F-111 led to concern over performance and rationale, and following an extensive analysis and tradeoff study, it faded from consideration.

By the spring of 1967, a more maneuverable 40,000 pound fighter had emerged, featuring variable sweep and somewhat lower cost. Concern over the variable-geometry capability led to a comparison with fixed-wing designs and this study continued for several months.

In July of 1967, the Soviet Union held a massive and historically significant airshow just outside Moscow at Domodedovo Airport. Western observers, for the first time in many years, were permitted to attend and what they had to report when it was all over, proved staggering. Many new fighter, bomber, and other combat aircraft types were displayed for the first time, not the least of which was an impressive and large fighter from the Mikoyan and Gurevich (MiG) design bureau. Later known as the MiG-25 and given the NATO identity codename of "Foxbat", this high-Mach-capability interceptor gave significant impetus to the F-X concept by underlining the need for a pure air superiority fighter.

In September of 1968, the Air Force and the OSD reached conceptual agreement on the F-X, which, at the same time, was allocated the F-15 designator. The Air Force now gained approval to pursue Contract Definition for an aircraft which would replace the McDonnell F-4E as the first line counter-air fighter in the 1975-1985 time frame.

In the ensuing Development Concept Paper (DCP) it was agreed that: (1) the F-15 would be a single seat, fixed wing, twin engine fighter in the 40,000 pound weight class (slightly less than an F-4 and about half that of an F-111); (2) a competitive prototype fly-off was not a suitable means for selecting a contractor; (3) the Navy VFX (Navy Fighter Experimental—soon to be designated F-14) was not suitable as an F-4E replacement, nor could the F-4E be modified to meet the threat; and (4) any F-15 ground attack capability would be a fall-out of its basic air-to-air combat capability. Once the DCP was approved, the Air Force was off and almost running with a new fighter program. Earlier, however, several aggressive and perhaps farsighted individuals in the Air Force and OSD had developed, and expressed, reservations regarding the F-X concept—particularly with respect to the aircraft's claimed higher performance, smaller size, and lower cost.

Rather than attempt to reconfigure a program which had already gained significant momentum within DoD, these individuals elected to reorient their efforts from making that aircraft more austere toward defining what the next Air Force fighter should look like.

# CHAPTER 2

# THE INTERIM; AND THE ROOTS OF THE MAFIA

The F-X Concept Formulation Studies were greatly aided by Maj. John Boyd, an Air Force pilot and graduate engineer who had been summoned to the Pentagon in October of 1966 to review the first F-X design and, following that, to be primarily responsible for the many tradeoffs and analyses which led to the F-15.

As a fighter pilot and tactics instructor at Nellis AFB, Nevada, in the late 1950's, Boyd had developed several theories (including his dictum that to prevail in conflict, one must work at a faster pace than the enemy or, turning it around, one must stretch the time it takes the enemy to run through the Observation, Orientation, Decision, and Action loop—or, as Boyd calls it, the OODA loop; Boyd maintains that all decisions can be broken into these four elements; in order to prevail, one must observe the situation, become oriented to the nature of the pressure, a decision must follow, and finally, action on the situation must be taken) which, when applied to air combat maneuvering tactics (i.e., dog fighting), assisted a fighter pilot in gaining a positional advantage over an adversary.

At Georgia Tech University in 1962, Boyd began to quantify and relate those aircraft characteristics which contribute most significantly to superior maneuvering performance. Basically, the elements involved were weight, drag, thrust and lift. These characteristics were, of course, well known to aircraft designers, but Boyd's unique connection of these variables directly to maneuvering was something totally new.

In 1963, Boyd teamed with Thomas Christie, a mathematician, who had been quick to recognize the promise of Boyd's emerging theories. Christie also had access to a computer which could be used to expand, refine, and simplify them. The resulting "Energy Maneuverability Concept" shed new light on air combat tactics, and because it lent itself to computer analysis and synthesis of design tradeoffs, proved to be of inestimable value in the design of new aircraft. The many design inputs could be varied until the desired or superior performance characteristics, for a given level of technology, surfaced. Boyd's concept was of considerable interest to the aircraft industry and because of this, he made his computer programs and techniques available to the industry's design engineers and he provided constructive criticism of new design studies. The fact that the McDonnell Douglas F-15 has much higher maneuvering performance than any previous fighter in the world is to a large extent due to John Boyd and his unprecedented tradeoff analyses.

Boyd did, however, have some serious reservations about the final F-15 design and equipment decisions, a number of which were made despite the contrary evidence developed by his tradeoff studies. Another doubter who seriously questioned many of the F-15's design requirements and priorities was Pierre Sprey. A weapon systems analyst on the staff of the Office of the Assistant Secretary of Defense Systems Analysis (OASD/SA), and in 1965, recently from Grumman Aircraft Corporation where he had been a research analyst and consultant, Sprey was an open-minded engineer with a penchant for questioning the unquestionable.

Because of this, while working with the OASD, Sprey became aware of, and at the same time, concerned over, the accelerating increase in the cost of weapon systems and the accompanying decline in the size of the major U.S. military forces. Accordingly, he set out to determine what was causing this trend and, if possible, to do something about it.

In the spring of 1967, Boyd briefed Sprey on F-X design tradeoffs and the rationale behind them. Sprey quickly realized that Boyd's analytical tools were the key to rational fighter design. After the briefing, the two men met and began discussing Sprey's concerns and theories.

So began a close association which, in time attracted a small, but intellectually powerful following and became a kind of fraternity often referred to in the halls of the Pentagon, as the "Fighter Mafia". The primary motivation of this group was concern over force structure based on the conviction that a greater number of small, very high performance fighters was preferable to a lesser number of larger, more complex, and therefore more costly fighters with somewhat compromised performance (there are almost infinite levels of weapon system complexity—and the same can be said for force mixes—but the "Fighter Mafia's" conviction was that, on balance, numbers are more important than complexity).

Boyd and Sprey were convinced that if the current fighter cost trend continued, it would be economically impossible for the U.S. to retain approximate numerical parity with the Warsaw Pact tactical fighter force. They concluded that the way to reverse this fighter cost trend and maintain the required parity was to omit all subsystems not absolutely essential to the mission; to resist the penchant for advanced technology engines; and to eliminate requirements for complex avionics systems, high—but seldom used militarily—top speeds, and excessive ranges.

Sprey also contended that because the military services (under policies inaugurated by Secretary of Defense Robert McNamara) were effectively constrained to fixed force structures, rather than budgetary limits, it was clearly in each service's interest to maximize the capability of each force unit as there was no incentive to acquire larger numbers of weapons by reducing unit cost. Thus Sprey recognized the need for greater austerity in fighter aircraft, and the incentives that might be exploited to achieve it. He also recognized that Boyd's analytical techniques could be used to determine if such an aircraft could be designed and still retain combat-relevant performance.

With the wealth of design data and tradeoff techniques being utilized in the F-X concept formulation, Boyd and Sprey investigated the feasibility of a more austere fighter even though in late 1967 the F-X design requirements appeared to be firm. They exercised tight design discipline and challenged almost every requirement, realizing that extracting just a little weight or complexity from each of many areas resulted in large over-all savings.

For example, scrutiny of new data revealed several previously unknown or at least misunderstood aircraft structural design criterion which could be relaxed with no loss of safety yet be used to reduce the weight of the aircraft. Boyd and Sprey concluded that by reducing the diameter of the radar antenna, reducing the number of unnecessary structural specifications, and reducing the top speed requirement (with the F-X, this was Mach 2.5) while limiting the avionics suit and other equipment

*The McDonnell Douglas F-15A Eagle is the end result of the tradeoff analyses successfully conducted by John Boyd and Pierre Sprey. Its exceptional performance would not have been possible without their input. McDonnell Douglas* planned for the F-X, a potentially attractive, lower cost alternative could be developed. They therefore began envisioning a smaller, less complex fighter, weighing about 33,000 to 35,000 pounds, which would have improved performance in all flight regimes except top speed.

In the spring of 1968, after putting together these rather extraordinary findings, Boyd briefed them at high levels of the Air Staff, and Sprey briefed the Commander of the Air Force Systems Command (AFSC). Some interest was expressed, but no serious attempt was made to increase the performance and decrease the F-X's size. At the time, this was considered somewhat of a setback for the fledgeling "Fighter Mafia" and accordingly, the small team spent the rest of the year "regrouping and retrenching".

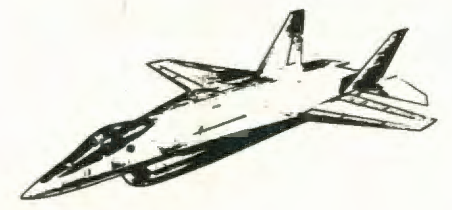
After their unsuccessful attempt to enlighten F-X proponents, Boyd and Sprey quietly set out to determine the extent of performance improvement that could be achieved by using the F-X tradeoff data to challenge *all* specifications and requirements. This effort evolved into a single-engine, less-than-25,000 pound fighter concept which Sprey called the F-XX. Subsequently, Sprey provided the F-XX design requirements to General Dynamics and Northrop for independent validations (somewhat inadvertently planting the seed that would soon give birth to the F-16 and F-17, respectively).

By late 1968, after reviewing a voluminous collection of contractor design data that was generated by the Northrop and General Dynamics studies, Sprey concluded that his 25,000-pound F-XX appeared valid. Basically, the requirements he had set were as follows: (1) slightly more range than an F-4; (2) no increase in weight or cost to achieve a ground attack capability or to achieve a top speed in excess of Mach 1.6; (3) a maximum weight for avionics of 500 pounds, including radar; (4) subsonic turning performance equivalent to that of an F-86; (5) structural specifications corresponding to the lowest used successfully on previous jet fighters; (6) a maximized thrust-to-weight ratio; and (7) stringent stability and pilot visibility criteria.

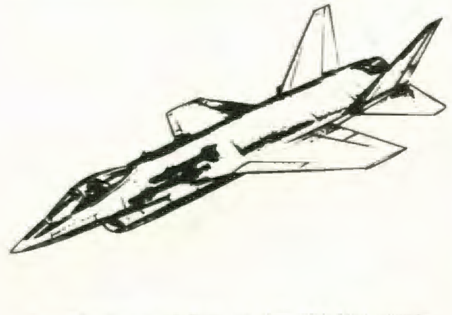
These parametric design studies showed that, by limiting requirements to only mission-essential equipment, increases of more than 100% could be achieved in both acceleration and maximum turning performance compared to the F-4 (no comparisons to the forthcoming F-15 were made in order to avoid upsetting entrenched F-15 proponents). Additionally, the studies showed that relative costs were reduced by more than a third, and indications were that further reductions in avionics and equipment would result in still lower weights (as low as 15,000 pounds) and costs with no loss in performance.

Sprey also contemplated a major change in the acquisition process, whereby two contractors would each build two F-XX prototype aircraft for the Air Force and two other contractors would each build two VF-XX prototypes for the Navy (two designs and four aircraft for each service). Additionally, he envisioned four competing engine contractors. The culmination of the competition was to be an aerial dogfight (without munitions) on the basis of which the two winning designs, one for the Air Force and one for the Navy, would be selected. He further postulated that, if the programs were managed using an approach of minimum documentation and manpower (similar to Lockheed's enigmatic Skunk Works operation), the total development program funding, including production startup costs for the two aircraft and engines, would be about half the combined F-14 and F-15 development cost estimates.

In early 1969, the incoming Nixon administration brought in Secretary of Defense Melvin Laird and Deputy Secretary of Defense David Packard to take over the reins of the DoD. In the meantime, the F-15 (alias F-X) program progressed towards source selection without major perturbation—even though members of the Air Force Studies and Analysis team had been working with Boyd's data and other tradeoff results provided by contractors. In fact, Maj. Gen. Glen Kent, who headed this team, decided the studies warranted another attempt at convincing the Air Staff that a lighter and less complex F-15 would offer significant benefits. A mid-1969 briefing to this effect by Lt. Col. Larry Welch was not supported at high levels and marked the last internal Air Force attempt to significantly alter the F-15 design.



*The FX-404 study which was the original lightweight fighter configuration; all other General Dynamics lightweight fighter configurations stemmed from this design.*
*General Dynamics*



*A mid-wing version of the FX-404 study with fuselage mounted Sidewinder AAM's. The fuselage mounting was investigated to discover if there were any advantages to it over conventional wing tip mounts.*
*General Dynamics*

Shortly after this, Boyd, along with the rest of the F-15 office, was transferred from the Pentagon to Air Force Systems Command (AFSC) headquarters at Andrews AFB, Maryland.

Sprey continued to update and promote his F-XX concept and maintained contact with Boyd. Sprey's theories were gaining additional support in OASD/SA and in the staff of the Office of the Director, Defense Research and Engineering (ODDR&E). Unfortunately, these sympathizers were not at the decision-making level.

In mid-1969, an OASD/SA draft Presidential Memorandum on Tactical Air was released containing the suggestion that both the Air Force and the Navy should adopt the F-XX/VF-XX concept as a possible substitute for the F-15 and F-14 and thus provide each service with a doubled force size. Not surprisingly, both services held their ground, arguing that so austere a fighter could neither defeat the high-speed, high-altitude MiG-25 nor carry the avionics needed to cope with enemy defenses.

By this time the Air Force and Navy had surmounted too many hurdles and were too close to realizing their own fighter designs to be swayed by a new and unproven design concept which might start the whole process over. This, coupled with an apparently inflexible Congressional force structure policy which led the services to pursue multi-purpose and thus more complex and expensive aircraft, virtually eliminated all chances that the F-XX/VF-XX program would be considered, much less adopted.

Both services rejected the proposal outright but the Navy's turn down was considerably more emphatic:

> "(These) basic concepts have been considered in detail by the Services during the informative stages of the F-14 and F-15, have been reviewed by DDR&E, and rejected in all decisions to date by OSD. The reconsideration of the concept (F-XX) as a viable alternative should have been turned down before submission to the services. . . .
>
> "In common with past papers by the same author, this study contains many fallacious assumptions, half truths, distortions, and erroneous extrapolations. Unsubstantiated opinions are presented as facts. Any rebuttals give the appearance of arguments against the rudimentary virtues of simplicity, high performance, and low cost."

Naval analysts also stated that the light weight claimed for the VF-XX was, in fact, unachievable and that the proposed thrust-to-weight ratio and wing loading could only be attained in an aircraft weighing in excess of 50,000 pounds.

The Air Force and Navy rebuttals of the F-XX/VF-XX concepts effectively blunted the OASD/SA initiative. In retrospect, however, it is clear that the "Fighter Mafia's" crusade for austerity had at least forced the F-15 planners and designers to do additional homework, and thus into producing a better fighter than they might otherwise have done. It is also reasonable to assume that, had this campaign for a more austere F-15 been successful, there might never have been a lightweight fighter!

In December of 1969, the Air Force selected the McDonnell Douglas Corporation as the F-15 prime contractor. Sources for the new afterburning turbofan engine (Pratt & Whitney with their F100) and the new lookdown radar (Hughes with their APG-63) were chosen shortly afterwards. With the acquisition strategy resolved and the prime contractor selected, the Defense Systems Acquisition Review Council (DSARC) convened on December 19, 1969, to review the F-15 program. Following this meeting (DSARC II), OSD cleared the program for engineering development—and twenty aircraft for test and evaluation were ordered. This was genuine cause for Air Force celebration and only a few foresaw the storm clouds that still lay ahead for the F-15.

# CHAPTER 3

# THE RETURN OF THE AUSTERE EXPORT FIGHTER

In 1969, then-President Richard Nixon unveiled his Nixon Doctrine. Among the many implied policy realignments noted was increasing pressure on America's allies to assume a greater share of the burden for their own defense.

This modification of U.S. foreign policy had strong DoD repercussions, particularly in the area of foreign sales policy. In October of 1969, the OSD advised the Services of the objectives and constraints that were expected to govern future military export sales. The new guidelines stated that: (1) sales proposals would be made only in response to a foreign country's internal initiative; (2) only those items needed to meet valid military requirements would be sold; (3) whenever practicable, prospective buyers would be encouraged to purchase directly from U.S. commercial sources rather than the DoD; (4) the DoD, however, would assist U.S. industry in making sales while avoiding all connotation of favoritism; and (5) items which the DoD believed a country did not need, could not afford, or could obtain better elsewhere, would not be sold.

For some time, the OSD had been concerned about the erosion of the U.S. competitive position in the international sale of aircraft. The European MRCA (Multi Role Combat Aircraft) program was gathering momentum and serious support, and French sales of the Dassault Mirage were increasing. Aware of this increasing foreign competition, studies and other efforts were initiated to examine an improved Northrop F-5 (the F-5-21 prototype had flown in 1969) and a less complex and lightened version of the McDonnell F-4E.

In September of 1969, Deputy Secretary Packard wrote Congress requesting approval for the Air Force to initiate development of a new "Free World Fighter" appropriate for use by U.S. allies. He foresaw a need, over the following five to six years, for approximately 325 aircraft to support South Viet Nam, Korea, Taiwan, and other allies. He argued that it was in the best U.S. economic, political, and military interests to develop and produce a relatively inexpensive but modern defensive fighter-interceptor for these countries, thus enabling them to become nationally self-sufficient rather than dependent upon the U.S. for their defense. Such an aircraft would also be attractive to other friendly countries which would procure their defense needs elsewhere if they could not be met in the U.S.

In an October 1969 letter to the Chairman of the Senate Armed Services Committee, Senator Stennis, Secretary Laird solicited support for the new IFA (International Fighter Aircraft—as the "Free World Fighter" was now called) program, stating that the fighter would have adequate capabilities to handle the existing threat, would be as inexpensive as feasible, and would be simple to maintain and operate.

With the Congress in a mood to accelerate the withdrawal of U.S. forces from Southeast Asia, the expected approval and funding were rapidly obtained. By the end of 1969, $58-million had been programmed by the OSD for IFA development in FY 1970 and 1971.

Companies which historically had produced fighter aircraft were not oblivious to these developments. Even though the IFA program did not have the final go-ahead and the specifications had not yet been determined, several companies were busily working on their own versions of an IFA based upon the requirements as they perceived them.

As 1970 began, there was a sense of uneasiness in certain elements of the Air Force. Even though the F-15 program had been approved for engineering development, critics of the program outside the DoD were numerous and vocal. There was also apprehension that in espousing the IFA—however austere and dedicated to foreign sales it may be—the Air Force might somehow be forced to inventory the aircraft and thus be forced to spend money on it rather than the F-15.

In the meantime, the IFA program had moved ahead at a steady pace and directives had been issued concerning its design priorities. It was, in fact, to be designed to provide Asian allies with a modern, multi-role fighter for home air defense and short-range close-air-support. Further, it was to be optimized for aerial combat in a maneuvering environment; it was to be maintainable by recipient countries; and it was *not* to provide a capability to launch independent, aggressive actions against neighboring countries.

Deputy Secretary Packard approved the Air Force's IFA program and RFP's (Requests for Proposals) were released to the aerospace industry in February of 1970. The RFP specified an aircraft capable of a 100 mile minimum radius of action on three missions: counter-air, point intercept, and close-air-support. The stated intent was that the new weapon system be tailored and produced essentially from existing or "off-the-shelf" hardware and be operational by 1974. The contract award was to be made before the end of 1970.

The RFP came as somewhat of a shock to many contractors, especially those that had envisioned designing and building an entirely new aircraft. Most soon realized that, even after removing all uncalled-for equipment and systems, their IFA candidates possessed inherent offensive capabilities well in excess of what was envisioned in the RFP. A few would-be competitors were thus quickly eliminated, and those who intended to submit proposals, with the exception of Northrop, sought additional ways of reducing the offensive potential of their designs. Northrop simply continued to work on their less provocative F-5-21.

While the IFA program gained momentum on what was amounting to a parallel track, Pierre Sprey continued spreading his F-XX gospel. In March of 1970 he was invited to present a paper at a Fighter Design Conference in St. Louis, Missouri, sponsored by the American Institute of Aeronautics and Astronautics.

Somewhat ironically, Sprey's presentation followed those describing the F-14 and F-15 programs. Not surprisingly, by the time his talk about weapon acquisition theories and the now-less-than-25,000-pound F-XX concept was completed, he had created quite a stir. Sprey, of course, had not expected to convert many of the conferees; he was satisfied to have had the opportunity to discuss his radically different approach and hoped that he had at least started people thinking.

*Northrop's F-5-21 project eventually became the F-5E. The prototype airplane, 71-1417, is shown here prior to official roll-out ceremonies at Northrop's Hawthorne, California plant. Northrop*

The "Fighter Mafia", at this time, had gained a new Air Force member. Colonel Everest Riccioni, a fighter tactician, test pilot, and graduate aerospace engineer, had been assigned to the Tactical Fighter Requirements Division of Air Force Headquarters in May of 1969. Riccioni had for some time been an advocate of smaller, less expensive fighters, but until he became aware of the Boyd and Sprey studies, he believed that cost could only be reduced by sacrificing performance.

In January of 1970, Riccioni took over the Air Force New Initiatives section (a position previously held by John Boyd) where he found more opportunities to pursue his ideas. Finally convinced by Boyd, Sprey, and another new "Fighter Mafia" member, Charles "Chuck" Meyers (a former test pilot and a then-independent aerospace consultant) that a small, lower-cost fighter could match or even improve upon the performance of larger fighters in most flight regimes, he began to think about fighters even more austere than those envisioned by Sprey.

Riccioni's motivation stemmed from several concerns. Like other "Fighter Mafia" members, he had strong apprehensions concerning cost and force structure, but he also had qualms over certain systems being developed for aircraft like the F-15, which he regarded as high-risk. He reasoned, for instance, that if any of these new systems—the lookdown radar, the 25mm gun, and the infra-red and radar guided missiles—should prove less than successful, the F-15 would not have the capabilities to justify its cost. Consequently, he felt it would be prudent to have a lower-cost alternative to fall back on if a worst case situation should materialize.

Riccioni, Boyd, Sprey, and Meyers now began to consider ways of improving fighter design requirements. Following several discussions with Air Force and industry designers, it was agreed that design mission rules should be more task-oriented. Riccioni then incorporated a very preliminary version of this new criterion—the use of maximum power turns and an acceleration to determine the combat fuel allowance—in the RFP for the IFA (Riccioni and Boyd were to significantly refine the task-oriented mission rule concept over the next two years). Riccioni also began to devote considerable time to developing design requirements for a "practical" lightweight fighter which would be powered by existing engines.

If Riccioni needed further incentive for his efforts, he gained it in the summer of 1970. Aware that the Navy had F-14 critics like the Air Force's F-15 critics, he began to wonder whether the Navy might also be quietly pursuing a more austere fighter. Through confidential inquiries he soon discovered almost a mirror image "Fighter Mafia" in the Navy working on at least three such designs with contractor assistance. To Riccioni, the possibility of the Air Force having to adopt yet another Navy fighter design was, to say the least, distasteful!

Riccioni knew that contractor analysis would be required to validate his theories and the evolving design rules. He also considered that a request through Air Force channels to initiate new fighter design studies at this time was unlikely to be approved. Conceiving a scheme which might accomplish his objectives, Riccioni put together a proposal. His idea, calling for a "Study to Validate the Integration of Advanced Energy-Maneuverability Theory with Tradeoff Analysis" was to be funded for a two contractor effort. In reality, Riccioni's "Study" was to be the preliminary design and analysis of three lightweight fighter configurations. Armed with evidence that the Navy was investigating several austere fighter designs, Riccioni "tested the water" at higher levels. Although there was only unofficial low key support, at least there were no disapprovals. Accordingly, he began to develop a more formal statement of work.

Riccioni believed that these ultra-austere, high-performance fighter designs should weigh less than 20,000 pounds (his goal, in fact, was 17,000 pounds) and have only the avionics and armament required for a visual day fighter (no radar or other systems not essential for the mission). He also stated that there was to be no requirement for a maneuvering capability above Mach 1.6. Six combat tasks or maneuvers were stipulated at a 225 mile radius and at a 30,000 foot altitude: an acceleration from Mach 0.9 to Mach 1.5; three complete turns at Mach 0.8; and two complete turns at Mach 1.2. Two advanced technology engines were to be utilized: either the Pratt & Whitney F100 (then a 23,000 pound thrust class afterburning turbofan under development for the F-15); or the General Electric GE-15 (then a 13,000 pound thrust class afterburning turbojet which, although still in an early development stage, embodied the same technology as the new and larger GE F101). Three different aircraft were to be designed: a single-engine fighter powered by an F100, a single engine fighter powered by a GE-15, and a twin engine fighter powered by two GE-15's.

While Riccioni's involvement with "Fighter Mafia" philosophies was growing, so was national criticism of DoD procurement policies. During the summer of 1970, Congressional, Senatorial, and media procurement policy critics became significantly more vocal and aggressive. As cost, schedule, and technical problems mounted in program after program, several study reports charged that "the entire DoD-contractor weapons systems acquisition process was out of control". The criticism culminated in the President's Blue Ribbon Panel Report in July of 1970 which substantiated the conclusions of several earlier studies and made a number of recommendations for improving the acquisition process.

Perhaps anticipating the Blue Ribbon Panel report, Deputy Secretary of Defense Packard released a DoD policy memorandum on major weapon system acquisitions in May of 1970. With emphasis on enabling the services to improve their management programs, the memorandum provided broad guidance in the areas of management, development, production, and contracting. Packard directed that the new policies be implemented immediately and that pertinent DoD regulations be changed or cancelled by September. It was clear that he contemplated a sustained effort to improve the DoD acquisition track record and expected to get positive results.

In a related effort, the Air Force made still another study of the F-15 requirements to reduce costs. This three month review, which began in July of 1970, considered and rejected several options: a new electro-optical sensor (called TISEO), a back-up radar missile capability, and development of a new short-range missile, the AIM-82. Except for a later modification to reduce aerodynamic drag, the F-15 requirements and design would remain essentially unchanged into the development program.

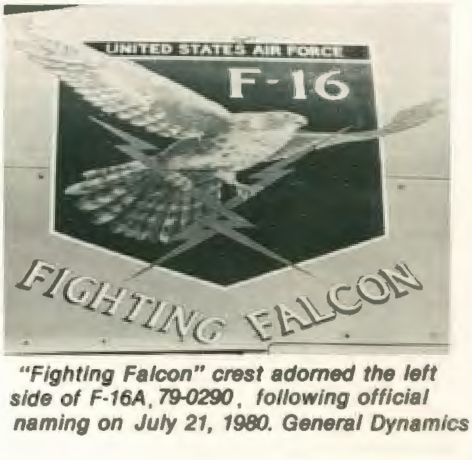
By now, the IFA competition had narrowed to four contractors: Lockheed proposed a J79-19 powered version of their improved F-104; Vought offered a stripped-down version of their F-8 designated the V-1000 powered by a J79-17; McDonnell Douglas offered an austere version of the F-4E; and Northrop, as expected, responded with the F-5-21.

After several OSD source selection reviews, few were surprised when in November of 1970, Secretary of the Air Force Robert Seamans announced that the Northrop candidate, now designated F-5E, had been selected as the new IFA. Few could question the decision as the F-5E was easily the smallest and least expensive offering and also the one that came closest to meeting the restrained IFA mission requirements.

Riccioni, meanwhile, was lining up the support needed to launch his proposed study. He found the right elements in OSD. They not only agreed with his concept, but more importantly, could ensure OSD approval of the nominal funds required (considered a crucial factor in keeping the study effort alive).

After receiving assurance in the fall of 1970 that $149,000 would be provided, Riccioni grew more open in his advocacy of the ultra-austere fighter. Where previously he had espoused the concept only at low and intermediate levels, he now sought higher level DoD audiences. Arguing that a lower-cost alternative would be needed in the event of major F-15 problems, he stressed the advantages offered by the type of fighter he proposed: it could be easily prototyped; its low cost was compatible with current budget constraints; it would permit a large and lethal fighter force; it could have extensive ground attack capabilities; its attractiveness to foreign countries would help reduce gold flow from the U.S.; and (for Air Force listeners) it would block Navy efforts to develop a similar aircraft.

While there was interest in his presentations, some senior officers felt that Riccioni was pushing too hard and that his exposure had become too great. In December of 1970, at a social function, Riccioni was questioned about his theories by Gen. John C. Meyer, the Air Force Vice Chief of Staff. After expounding his misgivings over the F-15 development program and his conviction that there was a need for an alternative design, Riccioni sensed that General Meyer's reaction was less than favorable. His suspicion was confirmed several weeks later when he was given orders calling for his transfer to Korea. Although severely disappointed, Riccioni actively monitored the progress on his study until the day he departed for his new assignment with an F-4 unit in the fall of 1971.



*"Fighting Falcon" crest adorned the left side of F-16A, 79-0290, following official naming on July 21, 1980. General Dynamics*

# CHAPTER 4

# THE REDISCOVERY OF PROTOTYPING

Establishing the detailed production configuration of a new aircraft requires many difficult decisions, each dependent upon prior resolution or avoidance of uncertainty. The early resolution of uncertainties in technology, performance, schedules, and costs is essential if efficient and effective development programs are to be achieved. One technique long used to resolve uncertainties in aircraft programs has been to build and test a prototype—an engine-airframe combination approximating, in full scale, the main features of a prospective production design.

Prior to and during World War II, prototyping was the normal way of introducing new aircraft. The procedure involved was relatively simple: a preliminary design was proposed to the service and, once it was accepted, a small team of designers and shopworkers would rapidly create and fabricate the aircraft. Significant features of the process were that the prototype was built around existing subsystems (particularly engines), specifications were little more than statements of performance and armament requirements, design and fabrication teams were small (typically under 100 people), the time required to complete the prototype was short (typically around three months to a year), and the cost was low. It was expected that many more prototypes would be built than would be approved for production. In general, only those prototypes showing promise during flight evaluations were funded for further modification to production configuration.

Unfortunately, this development approach was not flawless. Many prototypes were pursued that had little, if any merit, and conversely, good designs developed independently of service sponsorship were sometimes rejected or delayed (notable fighter aircraft examples include the North American P-51 and the Supermarine *Spitfire*).

The end of World War II marked the beginning of an era of increasing technological complexity. The jet engine signalled the demise of reciprocating engine aircraft and radar and television forecast the tremendous advances to be realized in electronics. While top speeds during World War II had been limited by the innate limitations of the piston engine, the jet engine opened the door to virtually unlimited speeds and altitudes.

After the sound barrier was broken in October of 1947, no one knew what the ultimate limit on speed and altitude might, in fact, be. When this was added to the capabilities promised by an emerging electronics industry, it can be readily understood why the services began to develop a voracious appetite for higher performance and more complexity.

Unfortunately, achieving all that was promised by the new technologies was not easy, rapid, or inexpensive. The thrust of a jet engine, for example, could be increased by raising its compression ratio, forcing it to operate at higher temperatures, and/or developing a more complicated fuel control system. But such improvements required closer maufacturing tolerances, use of more exotic materials, and extensive design and development programs.

Also, to fly at speeds and altitudes that previously had existed only in the dreams of pilots and designers necessitated such new aerodynamic and subsystem developments as swept wings, flying tails, ejection seats, pressurized cockpits, and hydraulic flight control systems. Complexity mounted and the state-of-the-art was pushed in many disciplines.

With this in mind, it is not surprising that the engineering staffs of the major aircraft companies and the staffs of the acquisition agencies grew in size. This expansion, as also might be expected, led to considerably more elaborate and heavily specified prototype developments. As the magnitude of the development task increased, it was in the interest of the aircraft companies also to increase the extent of early government commitment to a complete development and production program without competition.

The acquisition agencies, understandably, also expanded in their desire to exert greater influence over the selection and development process. Inevitably, therefore, the scope, duration and cost of development programs grew; the programs incorporated more and more concurrent subsystem developments (particularly engines and electronics); and there were fewer and fewer such programs.

As these programs became fewer, longer, and riskier, the possibility of serious failures became higher. In the late 1950's and early 1960's, after a succession of unsuccessful aircraft and missile programs, criticism began to focus on the prototyping process itself.

In an attempt to reduce the delays, risks, and costs of programs, the Air Force, with Secretary of Defense McNamara's approval, evolved the Total Package Procurement (TPP) concept—an acquisition strategy which used extensive preliminary paper analyses to reduce risk and increase contractor incentives for low-cost production.

TPP's objectives were commendable, but unfortunately, the strategy as implemented continued the trend towards increased duration, cost, and risk in the development process. Aircraft design teams suddenly swelled to 2,000 and 3,000 people and the cost of developing a new fighter climbed to $1 to $3-billion. Prototypes, per se, were still fabricated under TPP, but they were called development aircraft.

Because of TPP contracts, the new programs also proved exceptionally difficult to cancel.This was particularly awkward in situations where flight testing of the development aircraft indicated that cancellation would be prudent.

Following the unsuccessful implementation of the TPP concept to a number of military programs, the idea drew widespread attack from the DoD and Congress. By early 1970, criticism had grown to the point where Deputy Secretary of Defense Packard called for fundamental change. His immediate options were limited, however, as the two prinicipal ongoing development programs, the Grumman F-14 and the McDonnell Douglas F-15, had been initiated within the TPP environment and, at best, could only be modified.

While Packard attempted to develop his modifications, a number of TPP critics began pushing for the reinstitution of the older idea of rapid, less expensive prototyping. Not surprisingly, this quickly gained support in the Congress and in that portion of the aerospace industry not holding major TPP contracts.

One of the President's 1970 Blue Ribbon Panel Report recommendations was the formulation of a new weapon system development policy that would reduce technical risks by demonstrating hardware before it entered engineering development, thereby providing needed flexibility in acquisition strategies. A specific recommendation, in addition to abandonment of TPP, was "more use of competitive prototyping and less reliance on paper studies".

Almost coincident with release of the Blue Ribbon Report, the Air Force established the A-X program to develop a new, specialized close-air-support aircraft. Owing to its simplicity and low cost, plus the similarity of the candidate designs, competitive prototyping was a logical development strategy.

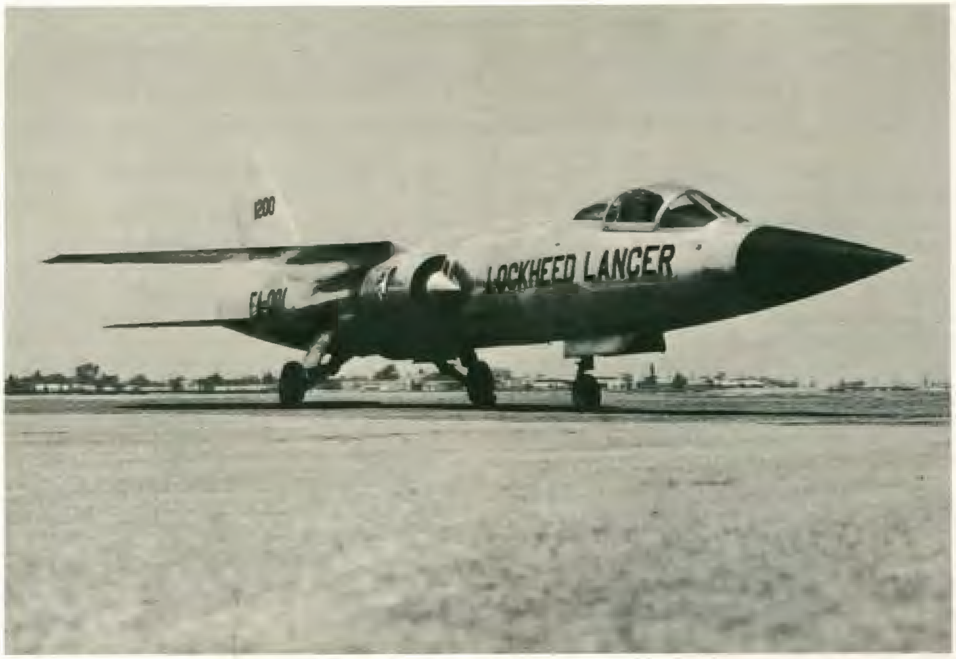
A-X prototyping, pitting the Northrop Corporation (A-9) design against that of Fairchild-Republic (A-10), was in fact, undertaken, thus bringing about the return of a proven philosophy that had not been seriously considered since the fly-off between the Republic F-105 and the North American F-107 in 1958.

The demise of TPP and the return to favor of prototyping were seen as good omens for Riccioni's disguised conceptual fighter design study. Northrop and General Dynamics now received study contracts in February of 1971, and work statements of the study went out to Lockheed, Vought, and Boeing shortly afterwards.

In February of 1971, heat was again applied to the F-15 program. The Surveys and Investigation Staff of the House Appropriations Committee (HAC/S&I) had completed a comparative study of the F-15 and F-14 and had concluded that while both aircraft were equally maneuverable, the F-14 could accomplish the mission of both aircraft whereas the F-15 could not. It was therefore suggested that serious consideration be given by the Air Force to the acquisition of the F-14. Advocates of commonality, of course, and critics of the DoD in Congress seized upon the study as further proof of military duplication and waste.

Rebuttals were forthcoming from the Air Force and these eventually got the upper hand in the ensuing arguments. Another battle to preserve the F-15 program had been won, but more battles were on the way.

Both the Air Force and the Navy faced a new attack by austerity advocates on Capitol Hill in May of 1971. The members of Congress for Peace Through Law (an organization numbering more than one-hundred, including Senator William Proxmire) issued a "Report on the F-14 and F-15 Tactical Fighters" with recommendations that were not at all complimentary to either aircraft. In brief, the report recommended FY 1972 funding of approximately $50 million to initiate development of a light, highly maneuverable F-XX type fighter that could be produced at a cost significantly below that of the F-14 and that could be used in combination with, or as a substitute for, the F-15. This proposal was eventually defeated, but it was evident that Sprey's ideas were gaining ground.



*Lockheed's CL-1200 was the most successful of the early contenders for the early F-XX austere fighter study. Skunk Works full-scale mock-up gave strong impression of being the real thing thanks to actual F-104 nose section and aluminum foil covered center and aft fuselage sections. Lockheed-California*

In very early 1971, strong and rapidly spreading interest in Riccioni's studies coupled with fear that the F-15 and A-X programs would monopolize the Air Force's tactical aircraft budget for the next ten years caused a lengthy procession of aircraft contractors to march up and down the halls of the Pentagon proffering proposals for new and advanced fighter designs. Along with a desire to have a demonstration fighter to market in Europe when it came time for the next major NATO procurement effort to get underway, the various contractors had serious concerns about the trend of DoD fighter procurement policies.

Lockheed submitted a new fighter proposal (called the CL-1200) on January 14th, Northrop followed on the 31st, and Boeing and Vought caught up in February and June, respectively. Each of these companies submitted aircraft that were designed to fulfill two important requirements—that of the austere F-XX type fighter for the Air Force, and that of a multinational fighter for sale in Europe and throughout the rest of the world.

Europe, in the meantime, had been slogging along in an attempt to finalize the design and prototyping of the complex and sophisticated MRCA. Four countries had, in fact, dropped out of the program, leaving Britain, Germany, and Italy to shoulder the burden and pay the bills. Unfortunately, the latter were proving to be much larger than intended as, like the U.S. had discovered with the F-111, designing and building an airplane for a broad spectrum of combat missions was very expensive.

Both Lockheed and Northrop were quick to conclude that it would be to their respective distinct advantages to get a prototype fighter of their own design into the air if at all possible. Lockheed, under the guidance of Kelly Johnson, took the CL-1200 proposal and garnered support in the form of a rather novel prototyping program that called for the potential customer(s) to absorb most, if not all of the prototyping expenses.

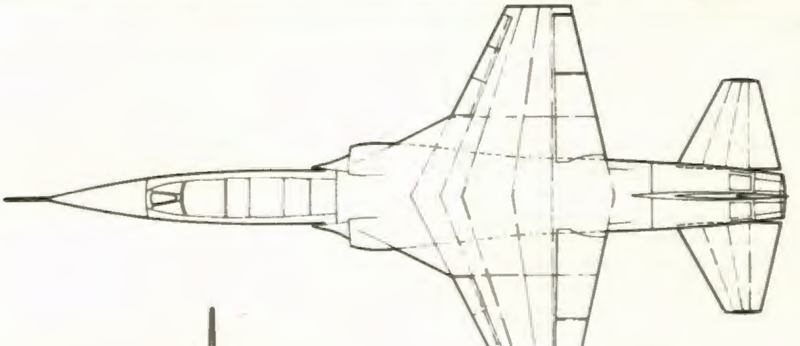
Johnson went to great extremes to promote the "new" Lockheed airplane, even arranging for several NATO countries to contribute F-104 parts and support for prototype construction purposes. Eventually a number of CL-1200 proponents within the Air Force developed a following and within a matter of months began pushing for funding and additional support. This eventually led to the CL-1200 coming within several signatures of progressing from drawing board to hardware.

Activity in the wings and corridors of the Pentagon became more intense as aircraft industry representatives, with concepts, design ideas, and potential prototype program proposals made their rounds. Vought representatives explored the possibilities of prototyping a two-seat version of their A-7 and a new version of their V-1000 (powered by a Pratt & Whitney F100 and designated Super V-1000); and General Dynamics representatives had several meetings with DoD personnel regarding their on-going design evaluations. Unfortunately, because of the rather serious loss of credibility sustained during the F-111 program, General Dynamics was significantly more cautious about making serious proposals. They insisted on waiting until their designs were supported by wind tunnel testing and thorough design analysis.

Not long after the General Dynamics DoD visit, Boyd and Riccioni visited all the contractors working on designs premised on Riccioni's study. Upon arriving at General Dynamics it was apparent that top management was not yet convinced that they should commit more than an exploratory effort to the new concept. Boyd, however, was soon able to impress them with its viability (this evolving from the study contract) and the result was a significant increase in company support.

In February of 1971, Boeing became the third firm to submit a proposal. Teaming with Dassault, whose attempts to warm the Air Force to the idea of buying the Mirage F-1 had met with a rather cool reception, Boeing proposed reengining the F-1 with a General Electric J79-19. A prototype, so Boeing claimed, could be built for $8-million.

The Air Force reaction to this idea was also less than enthusiastic. The F-1, even with the J79 engine, offered no apparent improvement over the F-4 and, in some areas, was actually a step backward in capability. Shortly thereafter, Boyd and Riccioni convinced the Boeing team that they should abandon further F-1 work and concentrate on a totally new airplane.



*Three-view drawing of CL-1200 illustrates extensive use of F-104 components and parts. From just behind nose wheel well, forward, airplane was essentially unchanged. Main landing gear were also stock F-104 components, as were many of the basic internal systems. Lockheed-California*

# CHAPTER 5

## THE LIGHTWEIGHT FIGHTER PHILOSOPHY GAINS MOMENTUM

In a memorandum to Deputy Secretary of Defense Packard, dated February 12, 1971, Dr. John Foster cited the numerous proposals that had been examined by the Air Force and suggested that the DoD might be well advised to fund such endeavors after sorting out the proposals and validating military needs. He suggested the initiation of an in-house tactical fighter and strike aircraft study to put the many variables of these mission-dedicated types into proper perspective. This would permit a better look at the potential usefulness of the proposed prototypes and, if they performed as expected, would allow the DoD to make sound decisions for the expenditure of funds.

Packard approved Foster's plan four days after it was written, annotating the following:

> "APPROVED: I think this could be a very useful approach. I am not sure we have to establish a specific requirement—there will always be a need for a better aircraft, especially if less costly. It is important that each program have these features. (1) Each should stand on its own two feet—two, at least, aircraft should be obtained. Only the price shall be firm. All specifications shall be open; (2) At least two projects should be authorized for each class of plane; (3) A plan for fly-off testing will be required; (4) It must be made clear that there is no commitment to go ahead with a further program; (5) At the same time we will lose benefit of this approach if, after a fly-off, we go back to some other competition for full development and production. In other words, the fly-off testing is the source selection if we decide to go ahead."

The guidance was clear and concise. Members of Foster's O/DDR&E staff, led by the Assistant Director for Air Warfare, Allan Simon, drew up a plan for a "Fighter/Attack Aircraft Prototype Study" and the Air Force began to consider the prototype proposals more seriously.

The Simon Study, as it became known, was to determine the validity of the reasons for prototyping, examine the attractiveness of the candidates, and, if appropriate, propose program guidelines. The possible purposes cited for introducing prototyping into the research and development efforts of the DoD were to: (1) remedy force structure deficiencies; (2) evaluate technology and designs not included in current programs; (3) keep the aircraft industry viable and the industry's design teams intact; (4) accomplish a portion of the basic development effort for the allies, thus ensuring the availability of superior aircraft and aiding the gold flow situation; and (5) provide procurement options in the event current force level requirements should change. To supplement the Packard guidelines, the study was to determine how often the programs should be initiated, which should come first, and the general magnitude of associated costs.

Concurrently with the Simon study, Lockheed and the Air Force had begun examining the CL-1200 proposal in more detail. Support for the program existed, but it was not particularly strong. Kelly Johnson, a man of some importance to the DoD, remained undaunted and renewed his efforts to sell the airplane. Though problems existed with the logistics of acquiring parts for the proposed prototypes, the program was still considered attractive and significant effort was expended in hope of developing a rationale that would withstand Congressional and public scrutiny.

Unfortunately for Lockheed, this was not to be. The program's demise, which occurred not long after its meteoric ascent to the top of the Air Force's prioritized "programs to be seriously considered for funding" list, was caused by concern over the awarding of a sole-source contract, the fact that it was almost certainly not the best available aircraft, and fear—fear that the CL-1200 was a potential threat to the F-15 (to avoid the visible threat to the new and still delicate McDonnell Douglas F-15 program posed by any new "F" designated aircraft, the CL-1200, for prototyping purposes, was designated X-27).

It is interesting to note that Johnson, during his CL-1200 promotional efforts, had compared the CL-1200's costs to those of the F-15. Not surprisingly, the results had evoked hostility in some quarters and it is very possible that this eventually led to the project's rather quick and painless death. It was assumed that if the CL-1200 had been successfully prototyped and flown before the F-15, critics of the latter program would have had good reason to push for cancellation, or at least, curtailment.

Northrop, while CL-1200 maneuvering was going hot and heavy in the DoD, had not been sitting still. On January 31, 1971, Thomas Jones, then Chairman and President of Northrop, had a letter offering two pre-production P-530 aircraft, delivered to the Air Force Chief of Staff, Gen. John Ryan. The letter started by describing Northrop's P-530-3 proposal and then proceeded to note that as good as its predicted performance was in a heavily loaded condition (i.e., with a full avionics complement), it could be greatly improved by the removal of all systems not essential for a single-purpose air-to-air combat fighter variant. The letter concluded by offering two austere P-530 aircraft to the Air Force for $15 million if the Dutch (who were seriously considering the airplane to replace their F-104's) would make the $100 million commitment required to initiate the production program.

The Air Staff assessed the pros and cons of the Northrop proposal and determined it to be roughly similar to those of the Lockheed offer except that the former had a better corporate financial position and involved a longer time from program go-ahead to first flight (twenty-seven months versus twelve).

The situation became somewhat more confused on March 16, 1971, when Jones again wrote to Gen. Ryan offering a substantially modified P-530 now known as the P-530-4. This aircraft would be referred to as an Air Research Vehicle (ARV) and would be used to test advanced aerodynamic and propulsion concepts. Of major significance was the fact that initiation of the P-530-4/ARV program was no longer contingent upon a foreign financial commitment, as had been the P-530-3.

The Air Force reacted to the Northrop proposal as they had the previous ones—interest was moderate, but not overly enthusiastic. Accordingly, Northrop was advised, on March 24, 1971, that, because of budgetary constraints, no positive action could be taken on the P-530-4/ARV but that it would be reviewed again along with other similar proposals at a later date.

Rejection of the P-530 proposal was a blow to Northrop, particularly in light of the fact that articles in both U.S. and European aviation publications were then stating (falsely) that the Air Force was about to fund the Lockheed CL-1200 program. The company found some consolation, however, in the fact that the Air Force had decided to fund the General Electric GE-15 (later known as the YJ101) engine that was now firmly tied to the P-530.

By the end of April, 1971, it was clear that for either the Northrop or the Lockheed proposals to be approved, they would have to become part of larger prototyping programs. This, in turn, would have to be supported by Congress.

In that same month, the Simon Study recommended that a comprehensive prototyping program and a plan to manage it be established. Deputy Secretary Packard then advised the services that he contemplated making available from $100-million to $200-million for such an effort.

The Air Force was quick to jump on the bandwagon. Having actively participated in the Simon Study, they were quick to initiate pursuit of the soon-to-be-released funds and did so vigorously.

Ostensibly to avoid any slowdown which might result from multiple agency involvement, the Air Force was in the process of developing a prototyping plan of its own including the identification of specific programs and establishment of ground rules. Both O/DDR&E and the Air Force agreed that the first effort should be in new fighter and interim STOL tactical transport designs.

These points were outlined to Mr. Packard by Secretary Seamans in a memorandum on May 7, 1971, which also stated that the Air Force would brief him on program plans by the end of July. Packard, who was now a strong and vocal prototyping advocate, approved the idea the next day and urged that the planning be expedited.

Reports of Packard's sense of urgency to establish one or more prototype programs quickly spread throughout the industry. Also, in late May, draft copies of the new DoD Directive 5000.1, "Acquisition of Major Defense Systems," were available, although it was not formally released until July 13th. This directive, one of several implementing Packard's broad policy memorandum of May, 1970, stressed the need for conducting advanced technology efforts independent of approved defense systems development. "Advanced technology effort includes prototyping, preferably using small, efficient design teams, and a minimum amount of documentation. The objective is to obtain significant advances in technology at minimum cost."

The aerospace industry now had a relatively clear picture of what was ahead. Accordingly, gears were placed in motion.

Vought was the first to respond. In a letter to the Deputy Secretary of Defense, dated June 28, 1971, Vought formally proposed a program calling for the construction and flight test of two V-1100 lightweight fighter prototypes.

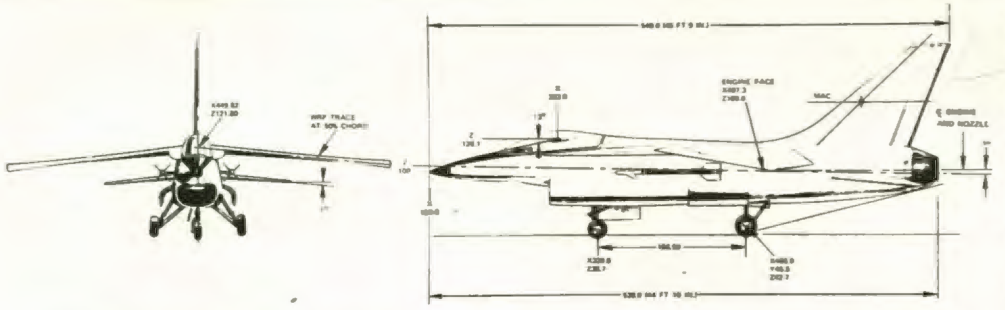


*Illustration showing the general layout and design of the Vought V-1100. Airplane was similar in over-all design approach to Vought's successful F-8 series, but had a different powerplant, a redesigned fuselage to accommodate the powerplant and numerous new systems, a generally lighter structure, and a revised wing for improved maneuverability.*
*Vought Corporation*

Vought had dropped the V-1000 concept and had created a totally new design in response to the F-XX specification input from Riccioni. The V-1100 weighed approximately 19,000 pounds, utilized an advanced technology fly-by-wire flight control system, and was powered by a single Pratt & Whitney F100. The price was $29.5 million for prototyping and preliminary flight testing.

Representatives from General Dynamics and Boeing (the latter company having heeded the counsel of Boyd and Riccioni and quietly abandoned the Dassault Mirage modification program) visited appropriate Pentagon offices in June to seek guidance and discuss their respective lightweight fighter designs. Though they were not yet ready to submit official proposals, it was obvious they were planning to do so in the very near future.

Northrop now made another significant move by proposing a program for a single-engine design, the P-610. This aircraft was based on the P-530, but was considerably smaller and weighed only 17,000 pounds (some 7,000 pounds less than the P-530-4). Although the design was preliminary and needed refinement, the P-610, with its lighter weight and smaller profile, was expected to have a better maneuvering capability than the P-530, particularly at higher speeds. Costs were estimated to be $47-million for prototyping and preliminary flight testing.

It was now becoming more and more obvious that interest in a fighter prototype program was growing. Support was already strong throughout the industry and new proposals were arriving on an almost daily basis.

Somewhat surprisingly, Northrop maintained a guarded enthusiasm for the idea of a fighter prototype program and, perhaps was even less enthusiastic about their P-610 design. The company was slowly being forced, by circumstances beyond its control, to significantly alter the NATO-dedicated, twin-engine, 25,000 pound P-530 configuration from the design which had evolved over the preceding 5 years. Now, in mid-1971, it was faced with an imminent Air Force prototype program calling for an austere, 20,000-pound or less, air-superiority fighter with only a questionable chance for follow-on production.

Northrop also knew that, if such a program materialized, competition would be intense. Northrop had to be one of the winners or else lose credibility in the NATO market. Another concern was possible Air Force preference for a single-engine fighter over a twin-engine, especially since the F100 was in development for the F-15.

The single-engine P-610 was, of course, a knee-jerk reaction to these unmentioned fears, as was a program to pare no less than 5,000 pounds from the P-530 configuration. The latter was not an easy task and in fact, entailed some design compromises before meeting with any semblance of success.

There was euphoria in other circles, however, particularly within the confines of the "Fighter Mafia". This group had been assessing the weights, performance, and other characteristics projected for the various new designs, and everyone was smiling. It was apparent that the companies had at last begun paying close attention to the iterative tradeoff approach evolved by Boyd, Sprey, and Riccioni. Mission rules, engineering specifications, and mission equipment were being systematically varied together with engine, aerodynamic, and structural considerations.

From their vantage points, Boyd, Sprey, and Riccioni regarded a serious and open tradeoff effort as the secret for success at all levels of technology and complexity. Accordingly, Boyd encouraged the contractors utilizing Riccioni's study to implement such an unconstrained approach in their design efforts.

Initial contractor use of the tradeoff approach had, in fact, resulted in the examination of many configurations before any well balanced designs began to emerge. However, the wealth of new design information exposed by the tradeoffs enabled the prospective contractors to submit vastly improved fighter designs compared to those produced by more traditional approaches. Industry was now generating the superior designs long envisioned by the "Fighter Mafia".

Secretary Packard's desire to expedite and fund a sizeable prototype program spurred an already considerable in-house effort in the Air Force Systems Command (AFSC). In late May of 1971, this effort expanded to become the Air Force Prototype Study Group with additional participation from Air Force headquarters and the Director of Laboratories. Brig. Gen. Ken Chapman, the Deputy Chief of Staff for Development Plans at the AFSC, was selected to chair the study group. His charter was to review and recommend candidate projects, generate a supporting rationale, and identify management and procurement approaches appropriate for prototype development programs. The working group to review and select candidates for prototype development was headed by Col. Lyle Cameron and his assistant, Col. John Boyd.

The study, completed in two months, focused on advanced development prototyping, which was considered to be complementary to the normal system developing process. It stressed that advanced development prototyping would improve the total acquisition process by providing, at low cost, a variety of demonstrated options to satisfy anticipated military requirements; permitting the initiation of projects, especially those involving high-risk technology, without the need for force structure justification; and fostering a viable design capability in industry.

New management procedures were called for. These included small Air Force program offices with direct participation in the contractor's program, minimum use of formal procedures (paper work) and specifications, maximum use of contractor formatted data and control systems, and integrated rather than sequential test programs. Streamlined procurement procedures were also proposed. Solicitations would be characterized by brief work statements, abbreviated RFP's (Requests for Proposals) and limited responses; evaluation and source selections would be accomplished by smaller groups at lower levels; and contracts would be specially tailored fixed-cost-types with open specifications and limits on government liability.

Of the more than 200 proposed prototyping projects screened, six were identified as candidate programs for initiation in FY 1972: an advanced, medium STOL transport (AMST); a very low radar cross-section vehicle; a large tanker aircraft; a remotely piloted vehicle; and a lightweight fighter (LWF). Approximately $20-million in FY 1972 and $80-million per year thereafter were the estimates for initiating and sustaining the advanced development program.

The Air Force presented the Prototype Study findings to Mr. Packard on August 5, 1971, and the reception was enthusiastic. Priorities had not been assigned to the six programs, and Packard was reported to state that, if the Air Force wasn't prepared to recommend candidates and move out, he would pick some for them. That the lightweight fighter was an obvious choice surprised no one; industry's interest in the European fighter selection and the efforts of Sprey, Boyd, and Riccioni had provided the completed homework necessary to initiate such a program in minimum time.

In an address to the National Security Industrial Association on August 11, 1971, Mr. Packard outlined the benefits of advanced development prototyping—the new approach to weapons development—and indicated the probability of funding a new experimental fighter program. He also stated that one of the major causes of cost overruns had been the commitment of major funds before technological problems had been solved, "industry promised more than it could deliver and the services were overly optimistic about what could be produced in a limited time with limited funds."

These latter comments brought a challenge from Senator Stuart Symington, a former Secretary of the Air Force, as to the status of the F-15 program. Packard's response, in addition to providing assurance that he was satisfied with the F-15 program progress, extolled the benefits of the new DoD advanced development prototyping program and the contemplated lightweight fighter program. While a lightweight fighter would not be competitive with the F-15 because of its "lesser range and capabilities," Packard asserted that "it could, if objectives were met, provide the Air Force with the option of complementing the F-15 force with inexpensive fighters."

In an August 25, 1971 Program Decision Memorandum (PDM), Secretary Packard approved Air Force plans and funding for both the LWF and the AMST. His direction was to fund two competitive programs for "an operationally suitable, lightweight fighter". The Navy was directed "to monitor the program to encourage carrier compatibility." Although not specifically mentioned, the other four Air Force prototype candidates remained under active consideration. Two days after the PDM was released, the Air Force Prototype Program Office (PPO) was established at ASD.

When Mr. Packard visited Congress in early September of 1971 to espouse his new advanced development prototyping plans and request funding for its implementation, the Air Force had an unusual problem; compared to the Army and Navy, the Air Force appeared to be considerably better prepared. Perhaps to provide a more balanced presentation to Congress, the Army picked up the RPV program and the Air Force dropped the large tanker aircraft. The Navy made a play for the LWF program funds with a counter-proposal for a small, vertical/short takeoff and landing (V/STOL) fighter, but Packard gave it only passing consideration. He had already decided in favor of the Air Force.

Also in September, General Electric requested that the Air Force fund a program to continue and accelerate the development of the YJ101 (the official Air Force designation for the General Electric GE-15) which, in fact, was very likely to be one of the competing engines in any forthcoming lightweight fighter competition. The proposed $10-million funding for this project would permit sufficient additional development to achieve a limited flight test rating or clearance within two years. The Air Force and General Electric had by now invested some $30-million in the program through research and development. Additionally, some 90% of the engine's detailed design had been released for manufacture.

During October and November of 1971, as the Congress debated the FY 1972 Appropriations Bill, many in the Air Force, especially at the Prototype Program Office, were engaged in preparing the documentation required to initiate the program. Some of the documents had to be very carefully conceived as there was considerable Air Force sensitivity to the challenge that the lightweight fighter presented to the F-15. For instance, the PDM direction regarding an "operationally suitable lightweight" fighter had caused concern. This was eased somewhat by Packard's explanation of the relationship between the two programs in his letter to Sen. Symington, but the Air Force remained externally vigilant where the F-15 was involved (and for good reason), as detractors were resolutely sniping at the program.

In a December 15, 1971 memorandum, Dr. Foster notified the Air Force that Packard desired to commence the FY 1972 prototype programs as soon as the Appropriations Bill was released by Congress. To accommodate this decision, OSD approval of the prototype programs would consist of the Air Force submitting a four-page Program Memorandum (PM) which would include a program description, a simple milestone schedule, a funding profile, and identification of those questions and issues to be resolved by the test program. These documents were requested within ten days. With the programs thus approved, the RFP's could be released to industry immediately following signing of the Bill.

The Air Force, anticipating such urgency, had completed "their version" of the PM's and expected to finish the RFP's and Source Selection Plans by November 17th. The remaining task was to reach agreement with the O/DDR&E staff on the contents of the PM's and particularly those for the lightweight fighter.

As the Air Force and OSD sought PM resolution, the Senate Armed Services Committee was holding hearings on the weapons system acquisition process. One of the several witnesses to appear was Pierre Sprey, who had left the OASD/SA staff in December of 1970 to enter private industry. He had been requested to testify at the December 8, 1971, session.

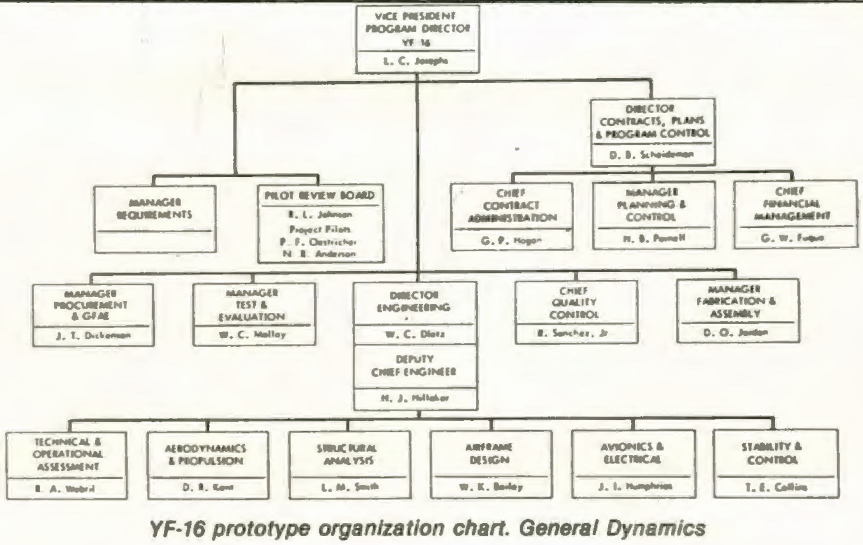
Not surprisingly, Sprey addressed the problem of the weapons cost explosion or, as it was referred to at the DoD, "gold plating". In prepared remarks he charged that military specifications and procurement methods had driven avionics costs up by a factor of ten over commercial versions, while reliability trends were running just the opposite (Sprey, for instance, argues convincingly that the Air Force and Navy's reliance on radar-guided missiles is the largest contributor to the decreasing numbers and increasing costs of U.S. aircraft. This conclusion is based on two things: {1} money spent on radar development is not spent on airplanes, and {2} the desire for longer radar detection ranges concommitently increases the unit price of aircraft design. The latter is caused by the fact that the longer the desired detection range, the larger in diameter must be the radar antenna. Unfortunately, larger radar antenna diameters lead to increased frontal area which, in turn, means increased drag. Increased drag can be overcome in only one way—larger and more powerful engines. Additionally, more powerful radar systems require heavier equipment for power generation—and weight, as well as drag, degrade speed, acceleration, and lift.); that the significant increase in airframe and engine costs was due primarily to the zeal to achieve the last one or two percent of possible performance—drag reduction, weight decrease, and/or thrust increase—thus necessitating the use of complex curvatures, exotic structures, and expensive material in manufacturing; and that these last few percentages of improvement were enormously more costly than the preceding ninety-eight or ninety-nine percent. Sprey also explained the F-XX concept in some detail and, in comparing it with the current lightweight fighter designs, stated that the concept had progressed well beyond anything he had envisioned in 1968.

Upon completion of his prepared statement, Sprey received some favorable comments from Senator Goldwater, but he came under considerable fire from Senators Symington and Cannon. Sen. Symington appeared to doubt Sprey's credibility, since he was not a licensed pilot. Senator Cannon, well-armed for the session, quoted portions of the Navy's 1969 F-XX concept analysis. The ensuing debate, which became heated at times, involved Sprey defending his concepts and trying to avoid F-14/F-15 issues. Senator Cannon also pursued this line of argument and attacked the capability of the lightweight fighter to "do the job that may be required". He cited as example, "the experience in Southeast Asia with our own lightweight fighter . . . the F-104", which, as Cannon understood it, had to be withdrawn because it "could not exist in the sophisticated environment".

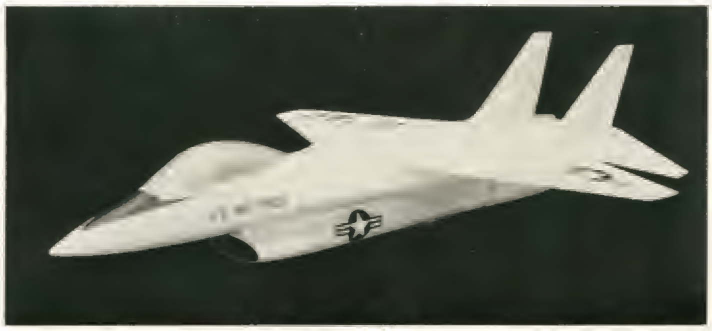
Sen. Cannon was also very critical of the lightweight fighter's range and payload capability, and included, for the session record, a statement he had recently made on the Senate floor entitled, "Lightweight Fighters—No Panacea". Near the end of the hearing, Sen. Goldwater asked Sprey if he thought the aims of the proposed lightweight fighter program were within the envelope of his F-XX study. When Sprey responded affirmatively, Sen. Goldwater's concluding remarks were: "I don't ask that, Mr. Chairman, to downgrade any of the testimony offered, but I think part of our trouble lies in some of these career civilians and men in uniform who just can't see anything valuable in a new idea; and I have seen some pretty good ideas shot down by these same people who would, I think, live to regret the thought that they had ever spoken against advancement. That is all I have."

Just six days later, on December 14, 1971, the FY 1972 Appropriations Bill was released and $12-million was approved for "the initiation of prototype development of a lightweight fighter aircraft and a medium STOL transport aircraft." No other prototype programs were funded for any service.

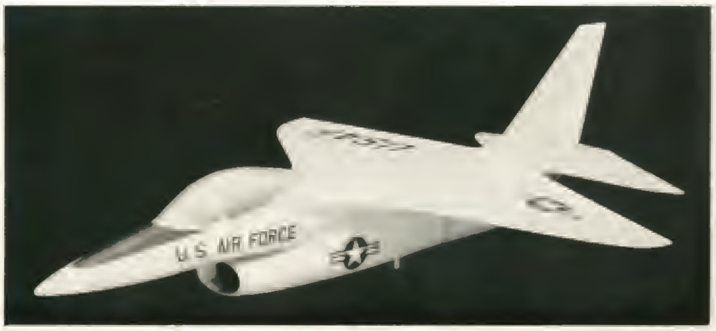
In spite of the holiday season, the tasks remaining to implement the program were rapidly accomplished. On December 20th, Assistant Air Force Secretary for Research and Development, Grant Hansen, approved the procurement actions, Dr. John Foster approved the PM on the 27th, and Acting Air Force Secretary John McLucas authorized release of the RFP and model contract to industry on the 31st. Thus on New Year's Eve, 1971, the Air Force officially launched the Lightweight Fighter Prototype Program.



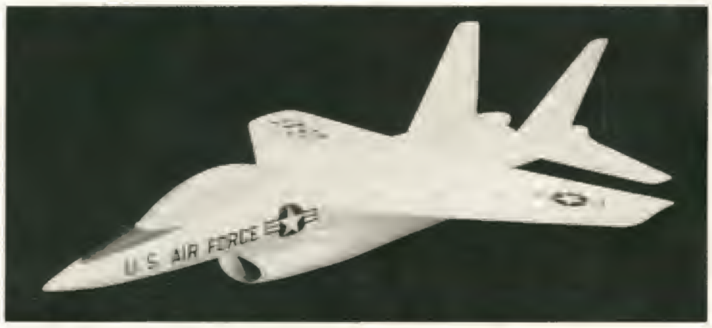
*YF-16 prototype organization chart. General Dynamics*



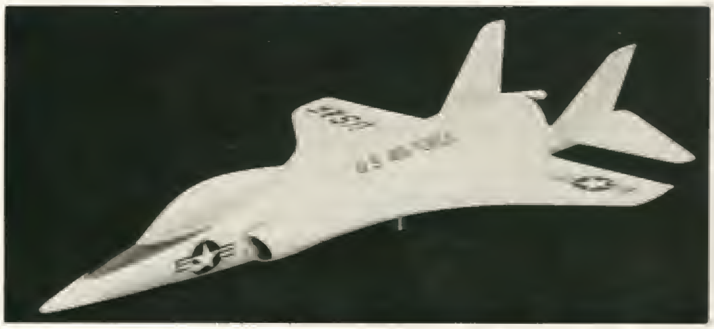
Original General Dynamics F404 lightweight fighter study. It was derived from the company's F-X (F-15) studies. General Dynamics



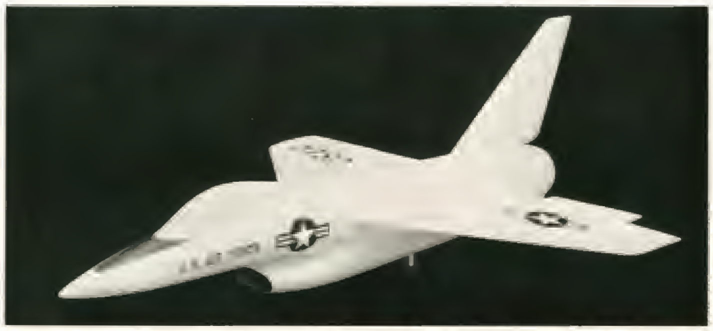
Configuration 785 variation with alternate wing and alternate nozzle. General Dynamics



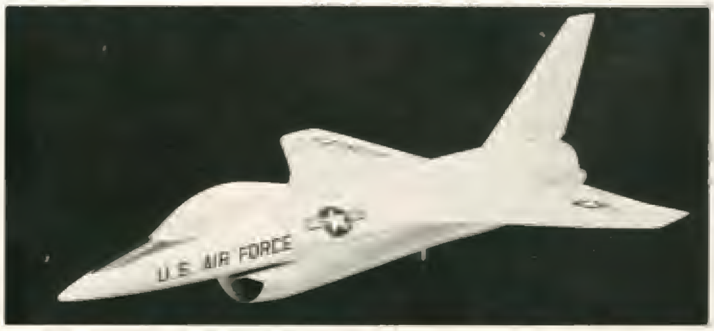
Configuration 786 with twin vertical fins. General Dynamics



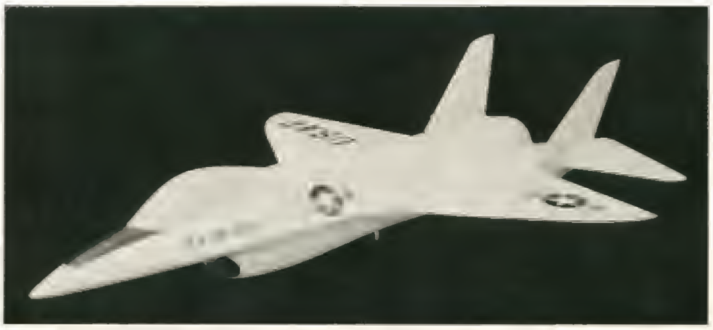
Early version of configuration 401F-0 with side inlets. Later version with 2-dimensional inlets, was tunnel tested. General Dynamics



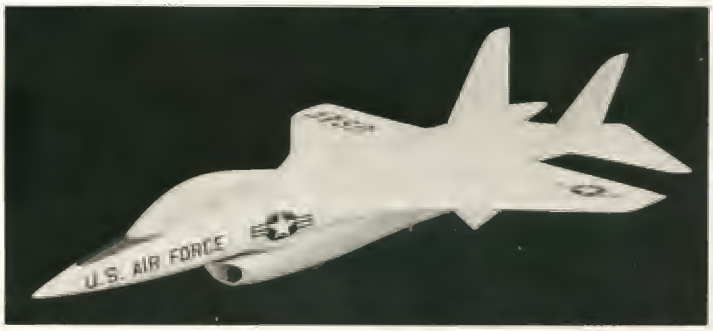
One of numerous configuration 401F studies. This particular version had an oval intake. General Dynamics



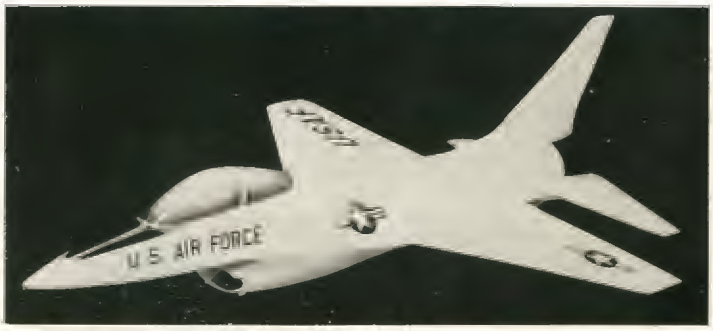
Configuration 401F-2 with single vertical fin and "smiley" inlet. General Dynamics



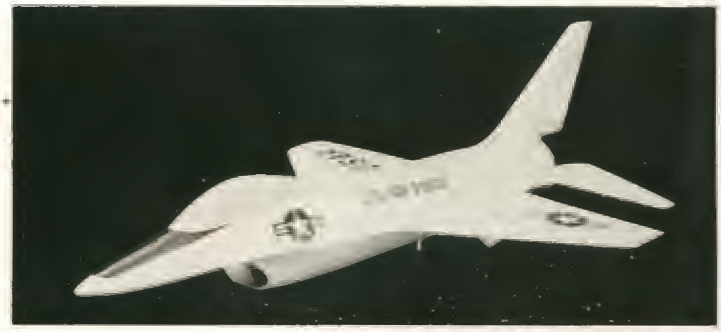
Configuration 401F-4 with twin vertical fins and oval intake. General Dynamics



Configuration 401F-4 with revised wing and "smiley" inlet.



Configuration 401F-5A with extended upper intake lip and near-definitive wing. General Dynamics



Configuration 401F-10A. This study, with configuration 401F-5A was used to decide the location of the horizontal tail. General Dynamics

# CHAPTER 6

# A STAR IS BORN

The Lightweight Fighter Request for Proposals were released to nine aerospace manufacturers on January 6, 1972. It was requested that responses to the RFP be returned no later than February 18th. The RFP was short, being only 21 pages long, and rather unique in that it asked for the contractors to design to goals rather than specifications.

The proposal contained performance and cost goals but not a lot of specifications. The bidders were to respond with a proposed aircraft in two ways. One, a maximum of fifty pages could be submitted to describe their aircraft and test program, and ten pages for cost and management; second, each would submit wind tunnel data and provide a scale model for wind tunnel testing. There was in effect a wind tunnel fly-off in addition to the evaluation of the proposals.

Other general requirements included a high thrust-to-weight-ratio, good transonic maneuverability, a simple avionics and fire control system package, a 6.5 g load factor, a suggested gross weight of 20,000 pounds, and a suggested unit flyaway cost in 1972 dollars of no more than $3-million (based on a buy of 300 aircraft at a rate of 100 per year).

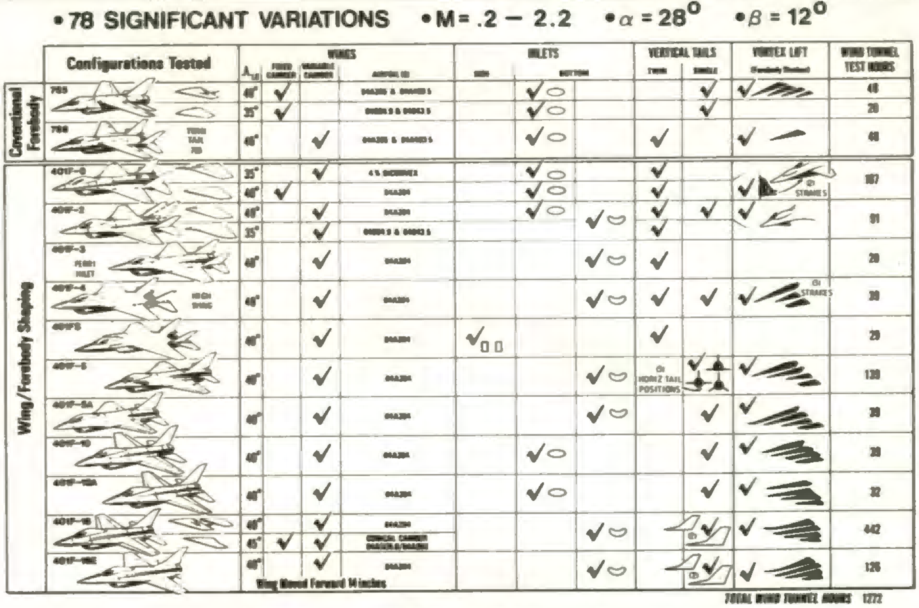
Five of the nine companies solicited, responded. These were Lockheed, Northrop, Boeing, Vought, and General Dynamics. Not surprisingly, these were the very same companies that had submitted unsolicited proposals in 1971.

The designs were delivered to the Air Force on February 18, 1972, and a preliminary analysis was completed during the following three weeks. On March 18th, the results were delivered to the Source Selection Authority (SSA) headed by Lt. Gen. James Stewart, Commander of the Aeronautical Systems Division.

The Air Force had concluded that the Boeing Model 908-909 design was the number one contender and the General Dynamics Model 401 design was a very close second. Northrop's twin-engine Model P-600 (a single engine P-610 was originally submitted, but was withdrawn following an expressed foreign interest in the original twin-engine P-530 by the Dutch) design followed in third place, Vought's Model V-1100 was fourth, and the Lockheed Model CL-1200 design was a distant fifth.

The SSA analyzed the findings of the preliminary analysis panel and after some revision determined the General Dynamics airplane to be the first choice, the Northrop airplane to be the second choice, and the Boeing airplane to be the third. The SSA's conclusion was partly based on the fact that the General Dynamics and Boeing proposals were very similar; thus to satisfy one of the main objectives of the prototype concept (validation of emerging technologies), the decision was made to award the second contract to a different approach—the Northrop airplane.

Air Force Secretary Robert Seamans now made the final decision. Following a conference with Gen. Stewart, and a further detailed analysis of the top three contenders, he elected to proceed with the prototyping and flight testing of the General Dynamics and Northrop designs. Accordingly, General Dynamics was awarded $37,943,000 for two Model 401's, and Northrop was awarded $39,878,715 for two Model 600's.


• 78 SIGNIFICANT VARIATIONS • M = .2 – 2.2 • α = 28° • β = 12°
Configurations Tested
WINGS
INLETS
VERTICAL TAILS
VORTEX LIFT
WIND TUNNEL TEST HOURS
Conventional Forebody
Wing/Forebody Shaping
785
786
401F-0
401F-2
401F-3
401F-4
401F5
401F-5
401F-5A
401F-10
401F-10A
401F-16
401F-16E
STRAKES
HORIZ TAIL POSITIONS
Wing Moved Forward 14 inches
48
20
40
107
91
20
30
29
130
30
30
32
442
126
TOTAL WIND TUNNEL HOURS 1272

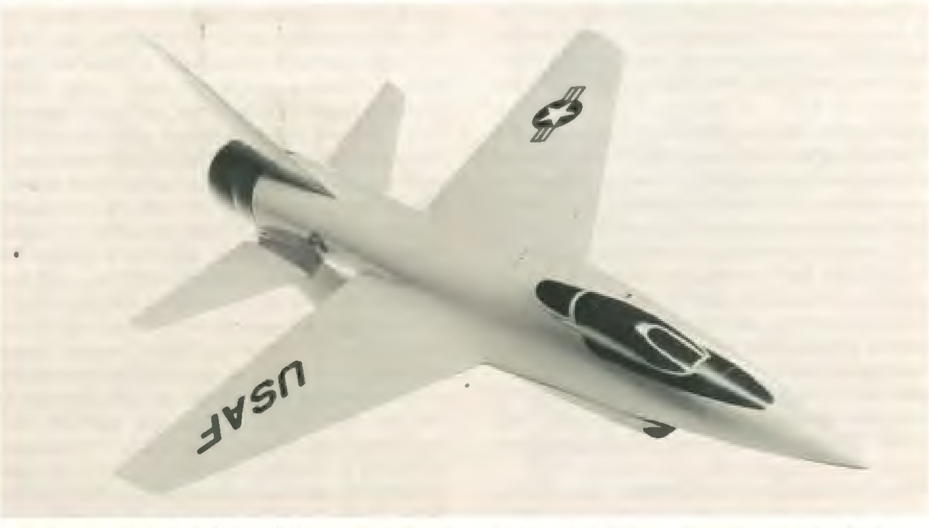
LWF force models tested. General Dynamics

Somewhat surprisingly, or so it appeared to outsiders who noted the reaction, the Air Force hierarchy was not at all happy with the state of affairs. The lightweight fighter program had been forced upon them by events beyond their control and it was readily apparent to all but the most foolish that the airplane represented a major threat to the highest priority program in the tactical air force, the F-15.

In a rather surreptitious move to kill, or at least hobble the new program, the Air Force, even prior to the decision to go ahead with the LWF, had begun a rather disorganized campaign to denegrate the airplane's "limited capabilities". Perhaps the biggest weapon at their disposal was the claim that the LWF would not possess the combat radius necessary for mission effectivity. Many figures were presented to bolster this claim, including the "fact" that the F-16's radius of action would be 150 miles compared to the F-15's 240 miles. As we shall soon see, the fallaciousness of this, and other arguments would soon embarrass the Air Force into silence.

During the months immediately following the decision to prototype the General Dynamics and Northrop LWF designs, now identified as the YF-16 and YF-17, respectively (and soon to be known as Air Combat Fighters, or ACFs—the Air Force, at the time, was unable to determine the origins of the program), the Air Force was pressed by House and Senate members to justify the need for the new airplane. This placed the service in a particularly awkward position as they in fact did not want it, and yet were politically and technologically motivated to accept it. The pressure to capitulate during Congressional testimonials was great, but miraculously, no major defeats were suffered.

In general, the Congressmen and Senators pushing for explanations were as ignorant of the predicament the services were in as the



*Boeing's Model 908 went through a large number of configuration studies before evolving into this near-definitive design (shown in model form). Like General Dynamics' successful contender, the Model 908 had a large under-fuselage intake and a single P&W F100 afterburning turbofan engine. Boeing Company* services themselves (though a small congressional team that had visited both Israel and Egypt had concluded that, opposed to the AF proposition that quality meant more than quantity, numbers of aircraft were indeed important to survive the high initial losses in a conflict). Forced by an inbred technocracy to strive for ever bigger and more sophisticated fighters (and, in fact, military equipment in general), it was assumed, and usually without question, that the solutions to future fighter needs lay only in the steady increase in complexity and sophistication (and size). It never once dawned on any of the interviewing Congressmen and Senators (with the noteworthy exception of Sen. Barry Goldwater) that other solutions were not only possible, but distinctly desirable.

The primary test objective of the lightweight fighter program was to determine the potential operational usefulness of the lightweight fighter and its advanced technological features. The test program was structured in three primary phases with participation by the contractor and the USAF (Air Force Flight Test Center and Tactical Air Command—and later, the Air Force Test and Evaluation Center) in all phases. Predicted data would be verified and a success oriented test program was planned to accomplish development testing, aerodynamic and systems evaluation, and operational factors. Determining the "victor" in the competition between the two sets of prototypes would be based on two things: (1) performance, and (2) cost.

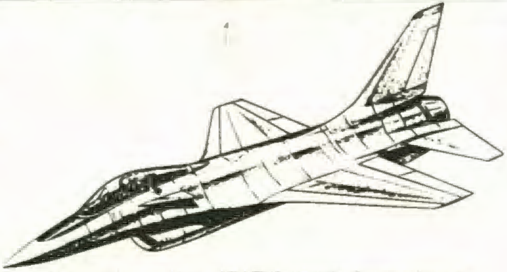
Each of the three major agencies would participate about equally. Evaluation testing would not repeat development testing and tests in several disciplines would be performed on any given flight.

General Dynamics and Northrop, as had been stipulated from the very first, were given a very free hand in the design and fabrication of their respective aircraft, while the Air Force had a major role in testing and evaluation. In addition to an integrated pilot structure for testing, the test engineers from the contractor and the USAF were integrated into a single team. Planning and data reduction were shared and all test data gathered was equally available to all test team members from which independent data analyses were made.

The overall management of the lightweight fighter program was the responsibility of the Prototype Program Office (PPO) under the Director of Prototypes (Col. Lyle Cameron who led the original prototype screening team) at the Aeronautical Systems Division, Wright-Patterson AFB, Ohio (known as the Systems Project Office, or SPO). The Air Force Flight Test Center (AFFTC), Edwards AFB, was the responsible test organization. Though this arrangement was not particularly unusual, the relationship between the various test organizations and the SPO, was. There were two Joint Test Teams (one for the F-16 and one for the F-17), each consisting of a contractor, the Air Force Flight Test Center, and the TAC, NASA, and Air Force Test and Evaluation Center (AFTEC) members. The head of both test teams was the AFFTC Joint Test Force Director. Each Test Team was monitored by a Test Management Council (TMC) consisting of the SPO director, and senior representatives from TAC, the AFFTC, the NASA, the AFTEC, and the contractor.

The General Dynamics Model 401, as the F-16 was known in-house, was the end product of a lengthy design study and wind tunnel test program that had been developed during the preliminary discussion days with Boyd and Riccioni by Chief Project Engineer Harry Hillaker, who had earlier quietly guided the project through several years of vascillating weak and strong company support. However, in organizing to execute the project, Vice President-Program Director Lyman Josephs and Director of Engineering William Dietz, were assigned in November of 1971. Additionally, a total of 650 personnel (250 engineers and 400 miscellaneous) participated in design and production. The project was divided into 28 work breakdown structure elements, with a manager responsible for each. Each element was assigned an engineering, tooling, fabrication, and assembly budget. A meeting was held every morning with element managers to track program progress.

The concept of the YF-16, as formulated by Hillaker, involved the prudent application of integrated advanced technologies and design innovations to achieve an aircraft that could satisfy the conflicting requirements of high performance and low cost. Emphasis was placed on small size and low weight in the application of advanced technologies to realize the best balance of combat capability (turn rate and acceleration) and lowest possible mission weight.



*A configuration 401F-5 study featuring a small canard mounted just below the canopy. Canard problems outweighed the benefits and the idea was discarded.*
*General Dynamics*

The key configuration elements that offered clear superiority in terms of maximum lift, directional stability, drag-at-lift, and inlet flow field were bottom inlet, wing-body blending, variable camber, and a single vertical tail. Additionally, it was determined that a single-engine configuration was nearly 4,500 pounds lighter than a twin-engine configuration (for a 500 nautical mile mission radius).

The F-16, as finally completed in prototype form, was a synthesis of advanced state-of-the-art technologies which had been explored for years, but until the advent of the new General Dynamics airplane, had never been blended together in a single airframe. As such, they resulted in tremendous gains in combat capability and marked a significant reversal of past trends (Technological gains have generally been achieved by the use of increasing sophistication, which has resulted in larger, heavier, more complex, and more expensive aircraft. Each new fighter since the P-51 has cost a minimum of 2.4 times its predecessor.).

As mentioned earlier, the concept of a low-cost, high-performance fighter evolved as a consequence of the marginal air-to-air combat effectiveness experienced by U.S. fighters in the Viet Nam war. In 1965, the combat "kill" exchange ratio at best, was 3.3 to 1, compared to 10 to 1 during the Korean War. Subsequently, the exchange ratio decayed to slightly better than 1.5 to 1, which, to a large extent, was the result of the shift in emphasis in the 1950's to air-to-air missiles and away from maneuverability.

Following the birth and subsequent death of the Air Force's Advanced Day Fighter (ADF) program that had the goal of developing a 25,000 pound fighter with a thrust-to-weight ratio and wing loading sufficiently high enough to maintain a 25-percent superiority over the MiG-21, the design program birth of a truly lightweight fighter occurred at several aerospace contractors, including General Dynamics.

As originally envisioned by Hillaker and his design team, the lightweight fighter was to be significantly lighter in weight than the ADF (18,000 to 20,000 pounds versus the ADF's 25,000), have a higher thrust-to-weight ratio (approximately 1.2/1.4 to 1), and have a lower wing loading. The political rationale was to have an airplane that would complement the forthcoming McDonnell Douglas F-15. Unit flyaway cost was targeted at $3-million.

The design objectives of the Model 401 (as the YF-16) became to maximize the usable maneuverability and agility of the aircraft in the air combat arena at a minimum of 500 n. miles from base. This objective was to be achieved within the constraints of system cost, complexity, and utility—which were to be prudently considered and balanced. To this end, emphasis was placed on small size and low weight/cost, on advanced technologies, and on design/aerodynamic innovation.

The attributes of small aircraft size were as follows:

(1) The smaller the size, the lower the drag, permitting a lower power setting for cruise and providing more excess thrust.
(2) The smaller the size, the higher the thrust-to-weight ratio for a given engine.
(3) Small size demands simplicity.
(4) The smaller the size, the lower the cost when other considerations such as material, detail design, and construction are equal.
(5) The smaller the size, the more difficult the airplane is to detect (detectability was a significant aspect in the marginal loss exchange ratio experienced in Southeast Asia).

Because of these advantages, design tradeoffs of wing loading, thrust loading, specific excess power, combat radius, and fuel fraction were conducted to define the configuration providing the best (highest) combat performance for the lowest weight.

The decision to pursue small size and lightweight was not without consequence, however. A popular misconception was that small aircraft have no range and little payload capability (used, as readers may recall, in Air Force arguments in favor of the F-15 and against the lightweight fighter). It is interesting to note that the relationship of size-to-range has been one wherein, as U.S. fighters have gotten progressively larger, the design (specification) mission radius has gone down and only recently has this trend been reversed. The YF-16, to underscore this point, during flight test proved to have a specific range (nautical miles per pound of fuel) of 0.25-0.39, compared to 0.15-0.20 for the F-15A and 0.08-0.12 for the F-4E. Additionally, although smaller in size, the YF-16 had a higher fuel fraction (0.28) than the F-15 (0.25), which meant that the smaller YF-16 with better specific range and higher fuel fraction had greater range than the larger F-15A.

Other Model 401/YF-16 features formulated and executed by Josephs, Dietz, and Hillaker and their design team during the design phase at General Dynamics include the following:

**WING PLANFORM**—Wing planform selection was undoubtedly the most critical of the configuration decisions affecting the ability of the airplane to achieve maximum performance at lowest weight. The combat conditions and priorities stated for the lightweight fighter made the wing planform selection even more difficult. These were:

Priority 1: Mach 1.2 turns
Priority 2: Mach 0.9 turns
Priority 3: Acceleration
Priority 4: Maximum lift (Mach 0.8 @ 40,000')

The first and third priorities required emphasis on wave drag, whereas the second and fourth required emphasis on drag-at-lift.

Four wing planforms (straight, swept, variable, and delta) were examined to satisfy these seemingly diametric conditions. A low-sweep, nearly straight wing appeared to be most suited to the design concepts. Of the other three planforms, only the delta offered any potential. Its low weight per unit of area, volumetric efficiency, and low wave drag made it look attractive. However, its high drag-at-lift and trim drag penalties eliminated it from final consideration.

**WING GEOMETRY**—The specific geometry of the selected wing (40-degree leading edge sweep) involved a trade of wing loading versus aspect ratio to achieve the best balance of turn rate and acceleration. A wing planform with an aspect ratio of 3.0 and sized to a 60 pounds per square foot wing loading resulted from this trade study.

**EFFECT OF SIZING WITH EXTERNAL FUEL**—Recognizing that fighter aircraft always end up with external fuel tanks, Hillaker and his design team decided to use an internal-external fuel concept in the sizing approach. Sizing the aircraft at the start of combat on internal fuel (with combat fuel and return/reserve fuel) and using external fuel for the outbound leg reduced the size of the YF-16 by about 1,470 pounds weight empty and 3,300 pounds gross weight. This approach produced a 5% increase in turn rate and a 30% improvement in acceleration time.

**ENGINE SELECTION**—The combination of engine cycle (bypass and pressure ratios) and number of engines was a very significant parameter in defining the gross weight (mission weight) of the YF-16. During the initial conceptual phase of the lightweight fighter program, General Dynamics evaluated two engines with different bypass ratios (BPR). These were the Pratt & Whitney F100 with a BPR of 0.72 and the General Electric YF101 with a BPR of 0.20. The former was examined for use in single engine designs, and the latter for use in twin engine.

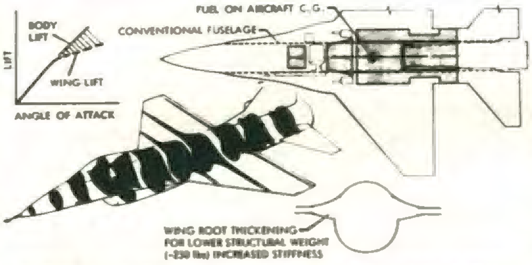
The evaluation of the two powerplants and their respective configurations was made by comparing the combined engine and fuel weights—including cruise, combat, and reserves—required to accomplish the design missions. The YF-16 design mission included a 500 n. mile high-subsonic cruise leg, a maximum afterburner acceleration, maximum afterburner subsonic and supersonic sustained turns, and a 20-minute sea level reserve. For this mission, the combined engine and fuel weight of the single F100-PW-100 turbofan engine was 7,882 pounds; for the twin YJ101 engines, it was 10,234 pounds. The twin YJ101 engines, including installation, weighed 1,024 pounds and required 1,328 pounds more fuel. For missions requiring longer ranges, lower altitudes, or higher speeds (at sea level or at high altitude), the differences would be even greater.

At cruise speed, the F100 was estimated to have a 7% higher thrust-to-weight ratio with a 25% lower fuel flow; at Mach 2.0 and 30,000 feet, it had a 41% higher thrust-to-weight ratio with a 6.5 percent lower fuel flow. In addition, it was found that, although two YJ101 engines were rated at 5,200 pounds more thrust at sea-level static conditions, the single F100 delivered 2,850 pounds more thrust at Mach 2.0 and 30,000 feet; and 7,500 pounds more thrust at Mach 1.2 and sea level.

The merits of one versus two engines, which had been (and still are being . .) argued for years, were also taken into consideration. Many evaluations of accumulated accident-rate data were made with varying conclusions. The number of variables involved in these evaluations made it impossible to arrive at a specific conclusion.

Hillaker and his design team eventually concluded that a single F100 turbofan engine with its higher bypass ratio provided the best balance of combat capability and mission radius for the lowest weight. A basic configuration meeting the stated performance/mission goals could be achieved at a mission weight of 17,050 pounds, whereas twin GE YJ101 engines resulted in a mission weight of 21,470 pounds. A single GE YJ101 configuration was also examined to see how small an aircraft could be defined, however, the configuration could not meet performance/mission goals.

BLENDED WING-BODY


FUEL ON AIRCRAFT C.G.
CONVENTIONAL FUSELAGE
BODY LIFT
LIFT
WING LIFT
ANGLE OF ATTACK
WING ROOT THICKENING FOR LOWER STRUCTURAL WEIGHT (-250 lbs) INCREASED STIFFNESS

- INCREASED LIFT: BODY LIFT ADDED TO WING LIFT AT HIGH ANGLES OF ATTACK ($C_L$ = .8)
- MORE VOLUME (+9%) WITH LESS WETTED AREA (-2%)
- LOWER WEIGHT
  - Shorter Fuselage (5.5 ft): -320 lb
  - Increased Wing Stiffness: -250 lb
- REDUCED TRANSONIC DRAG: Improved Area Distribution, Smoother Cross-Section Area Curve

**OTHER ELEMENTS OF DESIGN APPROACH**—The approach adopted to integrate the airframe/cockpit/avionics/weapons for multimission capabilities was to incorporate those features that would provide the best balance of air-to-air and air-to-surface capabilities over a broad spectrum of missions consistent with the cost goals. An increase in maximum takeoff gross weight and additional wing hard points were among the features incorporated to enhance the air-to-surface capabilities.

Structural integrity was not sacrificed to achieve low weight, nor were exotic high strength-to-weight materials used. In fact, the structural criteria established were fully compatible with the performance/mission capabilities. The load factor was established at 9.0g at full internal fuel as opposed to the Military Specification requirement of 7.33g at 80% internal fuel. The service life was established as 8,000 hours instead of the normal 4,000.

Although a basic part of the design rationale was centered around minimum avionics, it was recognized that future needs would likely demand more capability than initially planned. Thus, the avionics/subsystem architecture was defined to accept progressive improvement and growth.

Similarly, the necessity to accommodate radar guided missiles (such as the AIM-7 *Sparrow*) received considerable attention during the sizing process. A decision was made not to size the airplane for the design mission with radar missiles but to incorporate those basic revisions that would allow subsequent incorporation of a radar missile.

**CONFIGURATION RATIONALE**—Efficient, usable, high energy maneuverability demands the total integration of the overall configuration and the basic maneuver parameters. Although wing loading (W/S), thrust-to-weight ratio (T/W), and wing planform are the parameters most often used to define or measure maneuverability, they define only a maneuver potential rather than usable maneuverability. If maximum use of the maneuver potential is to be fully exploited, there can be no limitations or anomalies that inhibit the pilot from establishing any desired maneuver attitude or from progressing from one maneuver to another.

A number of configuration elements affect the capability of an aircraft to realize its full maneuver potential. In the case of the F-16, different alternatives in inlet configuration, wing camber, vertical tail configuration, and wing-body combination were available. Those configuration alternatives singled out—bottom inlet, wing-body blending, variable camber, single vertical tail—offered clearly superior capability in terms of maximum lift, directional stability, drag-at-lift, inlet flow field (distortion free through 32-degree angles of attack), and lowest weight.

Before the YF-16 configuration was finalized, 78 configuration variables having significant impact on the maximum usable maneuver potential had been thoroughly analyzed, evaluated, and wind-tunnel tested. All variables leading to the configuration definition were wind-tunnel tested at speeds from Mach 0.2 to 2.2 and at angles of attack and yaw up to 28-degrees and 12-degrees, respectively. The configuration variables included:

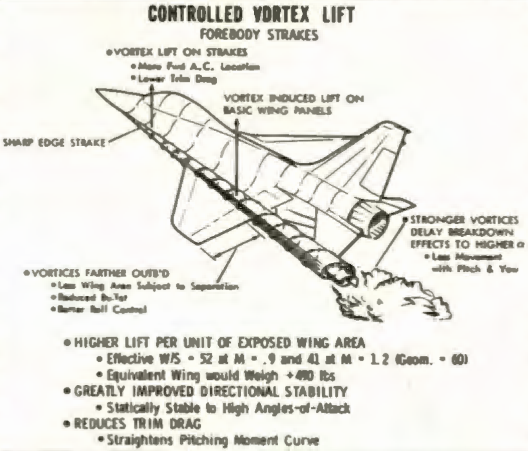
(1) Conventional and wing-body shaping
(2) Leading-edge sweep angles of 35, 40, and 45 degrees
(3) Fixed camber and variable camber
(4) Six airfoil sections, including constant thickness and camber and variations in thickness and camber from root to tip
(5) Side inlets and bottom inlets with two different shapes on the bottom inlet
(6) Twin and single tails with varying planforms, areas, and location
(7) A complete family of forebody strakes, including canards

The wind tunnel tests devoted to evaluating these variables totaled 1,272 hours of running time.

**INTEGRATED ADVANCED TECHNOLOGIES**—The YF-16 incorporated a number of advanced technologies that had not been used in previous operational fighters and, when coupled with certain design innovations, produced significant payoffs in terms of combat performance and cost:

(1) blended wing-body: The blended wing-body, or lifting body concept is achieved through a smooth fairing or blending of the wing and fuselage rather than the conventional angular intersection. This blending provides lift at high angles of attack, where the lift on the wing begins to diminish. The ability to "blend" allows a smoother distribution of cross section area (area rule) for low transonic drag. The thickening of the wing at the fuselage resulting from the "blending" gives increased structural depth at the point where loads on the wing are highest, thereby producing a weight saving of

*F-16's unusual blended wing-body design is well illustrated by this photo of F-16A, 79-0324. M61A-1 rotary cannon port fairing and associated gun cooling and gas bleed slots is readily visible. Aerofax*


FOREBODY STRAKES
• VORTEX LIFT ON STRAKES
• More Fwd A.C. Location
• Lower Trim Drag
VORTEX INDUCED LIFT ON BASIC WING PANELS
SHARP EDGE STRAKE
• STRONGER VORTICES DELAY BREAKDOWN EFFECTS TO HIGHER α
• Less Movement with Pitch & Yaw
• VORTICES FARTHER OUTB'D
• Less Wing Area Subject to Separation
• Reduced Bu-Tat
• Better Roll Control

**CONTROLLED VORTEX LIFT**

- HIGHER LIFT PER UNIT OF EXPOSED WING AREA
  - Effective W/S = 52 at M = .9 and 41 at M = 1.2 (Geom. = 60)
  - Equivalent Wing would Weigh +490 lbs
- GREATLY IMPROVED DIRECTIONAL STABILITY
  - Statically Stable to High Angles-of-Attack
- REDUCES TRIM DRAG
  - Straightens Pitching Moment Curve

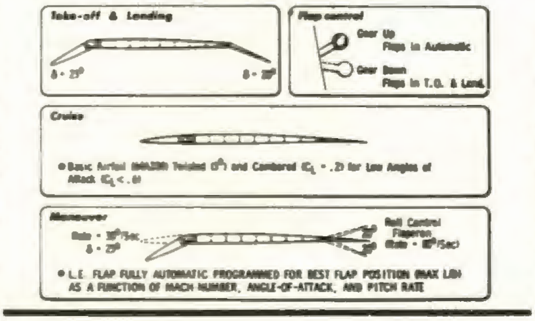
about 250 pounds. The blending also results in a high volumetric efficiency, which allows a shorter fuselage and, consequently, a lower weight for the required equipment and fuel volume. A conventional wing-body would require a 5.5 foot longer fuselage to get the same volume, adding 320 pounds to the structural weight, and also a larger vertical tail. Although the fineness ratio would be higher, area-rule would require higher local slopes, negating much of the supersonic drag-reducing effect and penalizing the subsonic minimum drag. In addition, the "coke-bottle" effect of conventional area-rule removes volume around the center of gravity right in the area where it is desirable to have volume for fuel, payload, and in some instances, the main landing gear. (Dick Whitcomb, the inventor of area ruling, had long suggested that too much emphasis was being placed on reducing the maximum cross-section area and not enough to the fore and aft slopes; a more even distribution of area was more important than the peak of the area, or volume; volume was added fore and aft of the F-16's wing to get more even area distribution and thus allow more volume at the c.g. where more volume could be better utilized for improved balance purposes.)

Wind tunnel tests verified that wing-body blending did indeed provide increased lift with increasing angle of attack. However, low energy vortices generated at high angles of attack resulted in lower directional stability than desired. Therefore, a means was needed to achieve the same results without the deleterious effects of such vortices. Forebody strakes provided the solution to this problem.

(2) controlled vortex lift: Controlled vortex flow proved to be the key to attaining maximum usable lift and excellent handling qualities without encountering directional divergence, wing rock, pitch-up, heavy buffet, and other instabilities that degrade tracking accuracy. Favorable management of separated flow at extreme flight attitudes was realized through the incorporation of sharp-edge forebody strakes, located on the forward fuselage ahead of the wing. The geometry of these strakes was defined to generate strong vortices with increased angle of attack to produce three primary benefits. Vortex lift was generated on the strake itself, producing a more forward aerodynamic center (a.c.) location, which in turn, reduced trim drag. By moving the intersection of the strake outboard on the wing leading edge, but not far enough to cause too much a.c. shift, the vortices could be moved outboard so that less wing area was subject to flow separation. The vortices were found to energize the flow over the part of the wing immersed in the vortex and thereby induce additional lift. The vortices generated at the forward edge of the strake improved the flow over the vertical tail, resulting in greatly increased directional stability. These vortices were strong enough to delay the vortex breakdown, or burst, well aft of the tail surface, so that lateral directional stability was retained up through maximum lift.

**AUTOMATIC VARIABLE CAMBER - MANEUVERING FLAPS**

- INCREASED DIRECTIONAL STABILITY AND REDUCED DRAG/INCREASED LIFT AT HIGH ANGLES OF ATTACK ( ≈12°)
- BETTER BALANCE BETWEEN TURN RATE AND ACCELERATION (LESS WING AREA, THINNER WING)


Take-off & Landing
δ = 25°
δ = 20°
Flap control
Gear Up
Flaps in Automatic
Gear Down
Flaps in T.O. & Land
Cruise
• Basic Airfoil (NACA) Twisted (3°) and Cambered (CL = .2) for Low Angles of Attack (CL < .6)
Maneuver
Rate = 35°/Sec
δ = 25°
Roll Control Flaperon
Rate = 80°/Sec
20°
20°
• L.E. FLAP FULLY AUTOMATIC PROGRAMMED FOR BEST FLAP POSITION (MAX L/D) AS A FUNCTION OF MACH NUMBER, ANGLE-OF-ATTACK, AND PITCH RATE

When blended wing-body lift is integrated with vortex-flow-induced lift, even higher lift per unit of exposed wing is produced at lift coefficients above 0.6. Although the geometric wing loading is 60 pounds per square foot, the effective wing loading resulting from these vortex benefits is 50 pounds per square foot at Mach 0.9 and 41 pounds per square foot at Mach 1.2. To generate the same amounts of lift, an equivalent wing would need both a higher aspect ratio and more area. Such a wing would increase the empty weight of the airplane by 490 pounds.

Wind tunnel testing verified additional lift and a significant improvement in pitching moment. Similarly, the wind tunnel results verified the directional stability improvement and showed a big buffet improvement that permitted maneuvering at maximum lift with only mild buffet effects.

(3) automatic variable camber: Variable camber was the key to defining a wing planform that provided a balance between subsonic and supersonic maneuver conditions and acceleration while maintaining outstanding handling qualities and tracking precision throughout the Mach 0.8 to Mach 1.6 combat arena. The use of variable camber allowed a lower wing thickness (4%) and aspect ratio (3.0) for improved wave drag with a lower sweep (40-degrees) and produced the desired level of drag-at-lift for transonic maneuvering. The benefits of higher sweep were realized without susceptibility to dynamic and aeroelastic anomalies. Similarly, the drag-at-lift and handling quality benefits of a thicker fixed-camber, lower sweep wing were realized at a lower aspect ratio and, thus, lower weight.

Variable camber also satisfied the demands of airfoil shaping for flight conditions that are normally in conflict. The camber requirements for takeoff and landing, subsonic cruise, high 'g' maneuvering, and supersonic flight were so varied that they could not be satisfied by a single fixed camber.

The use of leading-edge flaps, usually slotted, is not new. In this instance, plain, single-in-chord flaps were selected instead of the more sophisticated slotted types because of their simplicity and because this flap could be used throughout the flight envelope and could be scheduled to provide the best flap position (camber) for the desired flight condition. The flaps were automatically programmed for best position/deflection as a function of Mach number and angle of attack. The flap actuation rate (35 degrees per second) was compatible with the airplane pitch-rate potential so that it was impossible to maneuver at a rate that would "outrun" the flap position.

The basic airfoil was cambered and twisted for optimum efficiency at subsonic cruise and for supersonic maneuvering. Additional camber and twist would degrade the acceleration capability and would reduce the maximum speed.

Leading-edge-flap deflection reduced the pitching moment at high lift coefficients, thus yielding much higher trimmed lift and lower trim drag for increased turn rates.

The leading-edge-flap also greatly influenced the vortex flow contributions generated by the forebody strakes. Scheduling the leading-edge-flap deflection with angle of attack improved the vortex contribution to lateral-directional stability by as much as 400% at high angles of attack and reduced the buffet intensity to a light-to-mild level up through a 9.0 g maneuver.

For supersonic flights (cruise and acceleration), the leading and trailing flaps were deflected up 2 degrees to reduce the camber penalties at those flight conditions.

Although the leading-edge flap did not contribute significantly to takeoff performance, it was deflected during takeoff and landing so that only one common flap position (leading and trailing edge) was required. The flap control was tied in with the gear retract handle so that the flaps were fixed in the takeoff and landing position when the gear was down and was set to the automatic mode when the gear was retracted. If there was a failure in the automatic mode, the flaps remained in the failed position. Such a failure would reduce maneuver capability but presented no significant problem during landing.

Scheduled leading-edge-flap deflection, or variable camber, produced a big increase in directional stability and a significant decrease drag-at-lift over that provided with a fixed camber.

(4) fly-by-wire (FBW): Perhaps the biggest step made in the application of advanced technology was the decision to use an all-electronic fly-by-wire flight control system instead of a conventional hydromechanical system with its linkages and cables. The reduced lags and overshoots afforded by the better kinematics inherent in the fly-by-wire system resulted in greatly improved and expanded flying qualities, which significantly improved the response and accuracy of the pilot-airframe system. Precise, nonvarying control of aircraft response throughout the flight envelope was implemented more effectively with FBW than with conventional systems.

The flight control system was a high-authority command and stability augmentation system. A "g" and roll-rate command maximized response in the pitch and roll axes throughout the flight envelope. The "g" command also provided constant stick force per "g" in the pitch axis. Static and dynamic stability augmentation was provided in the pitch and yaw axes, with damping augmentation in the roll and yaw axes.

Spin/stall prevention was achieved through limiting function that maintained the angle of attack within useful limits during a maneuver condition.

Turn coordination was provided through an aileron-rudder interconnect and a roll-rate-to-rudder feedback. This arrangement improved turn performance at high angles of attack, thereby increasing the usable angle of attack through the elimination of any possibility of roll reversal.

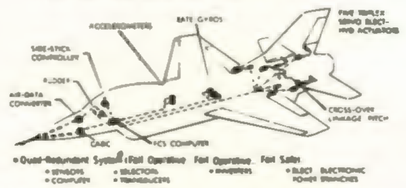
Reaction of the aircraft to the firing of the gun was effectively compensated through rudder and flaperon inputs commanded automatically by a firing signal to the gun.

The weight savings resulting from absence of cables, linkages, ratio-changers, etc., were translated into redundancy. The redundancy level and freedom of routing afforded by wires provide improved reliability and increased operational survivability.

(5) relaxed static stability: The high reliability and the redundant features of the current high-authority command and stability augmentation flight control systems made it no longer mandatory to have free-airframe (static) stability. Flight operation with an unstable, highly controllable, free airframe was practical.

### FLY-BY-WIRE (FBW) FLIGHT CONTROL SYSTEM

- REDUCED LAGS & OVERSHOOTS AFFORDED BY BETTER KINEMATICS OF ELECTRONIC CIRCUITRY PROVIDES:
  - GREATLY IMPROVED & EXPANDED FLYING QUALITIES
  - SIGNIFICANTLY IMPROVED RESPONSE & PRECISION OF PILOT-AIRFRAME SYSTEM FOR HIGH TRACKING ACCURACY



- HIGH-AUTHORITY COMMAND & STABILITY AUGMENTATION
- STRUCTURAL PROTECTION & SPIN/STALL PREVENTION - Maintains $\alpha$ and $\beta$ within Useful Limits During All Maneuver Conditions
- COMPLEX PILOT FEEL SYSTEMS ELIMINATED
- SIMPLIFIED AIRCRAFT STRUCTURE - Ease of Routing
- GUN COMPENSATION - Yaw & Roll Compensation for Boresight Excursion During Gun Firing

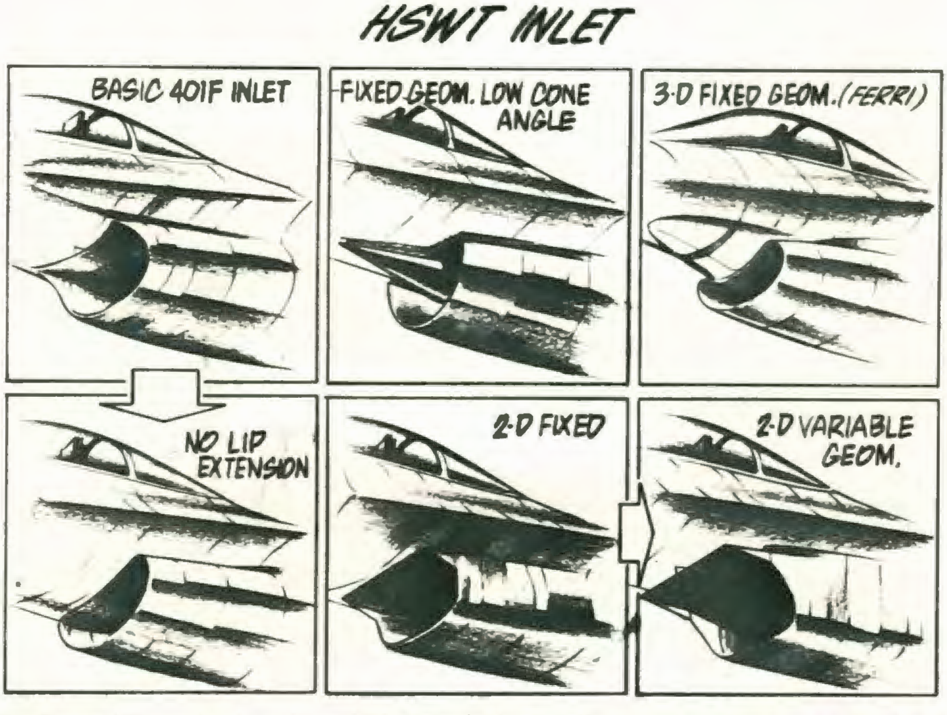
In a conventional configuration design approach, the center of gravity is generally located at 3% of the mean aerodynamic chord forward of the aerodynamic center (a.c.) to provide positive static stability. The horizontal tail deflection required to balance the moment resulting from this relationship causes trim drag and creates a down-load on the horizontal tail. The technique used in the YF-16 of locating c.g. aft of the a.c. allowed a reduced or negative static margin (relaxed static stability) in the longitudinal axis during subsonic, low-angle-of-attack flight. The airframe was dynamically stable about all axes and was statically stable at all angles of attack above 9-degrees and at all supersonic speeds. The advantage of this technique was that the horizontal tail size or the tail deflection angles required for high-g maneuvers and supersonic flight were reduced, with a resulting reduction in trim drag. In a highly maneuverable fighter, trim drag at high "g" is a significant parameter. In the YF-16, the trim drag at high load factors and at supersonic speeds was reduced by as much as 50%, which increased the supersonic turn rate by about 15% and the subsonic turn rate by about 8%. The reduced trim drag also reduced the mission weight by 400 pounds. An additional weight benefit resulted from the more favorable structural load distribution that accrued from reduced tail loads and the lifting tail.

When coupled with fly-by-wire, relaxed static stability produced a maneuvering airplane with more than twice the response of conventional fighters which further enhanced its combat agility.

(6) vertical tail selection: As discussed previously, lateral-directional stability was enhanced by the interaction of the forebody strake and the leading-edge-flap deflection. This interaction had a significant influence on the vertical tail configuration. Many single- and twin-tail variations—including tail size, planform, longitudinal location, and lateral location and cant angles for twin tails—were examined and wind tunnel tested.

Previously available wind tunnel data had indicated that twin-tails would provide a higher level of directional stability, particularly in sideslip; however, this data was limited to 15-degrees angle of attack. Eight of the 18 wind tunnel tests that were run to define the vertical tail configuration were made with twin tails. The maximum positive stability angle-of-attack measured was 21 degrees. Analysis indicated that vertical tail height above the wing chord plane was the dominant design parameter.

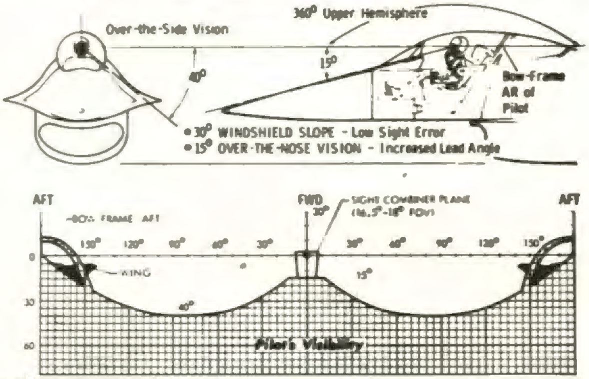
During the wind tunnel tests, there were certain strake shapes that were beneficial to a.c. location and vortex-induced lift on the wing,



*The General Dynamics High Speed Wind Tunnel in San Diego was used to study a number of inlet configurations, the most important of which are illustrated here. The basic 401F inlet was considered the best compromise in terms of cost, all-round performance, and complexity; the fixed geometry low cone angle inlet looked good at supersonic speeds but was not too good at high angles-of-attack; the Ferri inlet was designed to provide some "pre-compression" to improve the inlet characteristics; the no lip extension inlet was simply an attempt to get a simpler, lighter inlet but it didn't work as planned; the 2-dimensional fixed inlet was as good as the oval/"smiley" inlet performance-wise, but was heavier due to pressure requirements; and the 2-dimensional variable geometry inlet was also quite good, particularly at Mach 1.5 and above, but weighed 400 pounds more. General Dynamics.*

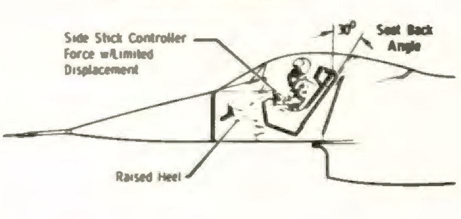
**MAXIMUM VISIBILITY**

UNOBSTRUCTED IN PRINCIPAL SEARCH AREA



**COCKPIT INCREASES 'g' TOLERANCE**

IMPROVED PILOT PERFORMANCE



INCREASED 'g' TOLERANCE (Demonstrated on Centrifuge)
- 1.5 "g" Improvement in Pilot Tolerance Level
- 30-55% Improvement in Tracking Error at High "g"

SIDE STICK CONTROLLER
- More Precise Control Inputs
- No Pilot Feed-back Under High "g"

but degraded directional stability when used with twin tails. Although not thoroughly explored, it appeared that twin tails were quite sensitive to strake configuration and, therefore, constituted a greater development risk.

The single vertical tail configuration not only provided the highest level of lateral-directional stability but also had the lowest exposed area, which resulted in lower structural weight and lower friction drag.

(7) inlet/airframe integration (bottom located/normal-shock inlet): Although a number of aircraft had been flying with fixed, normal-shock inlets, the expanded application of such an inlet into the high-transonic/supersonic region was not previously thought feasible or practical (though it had been flown to speeds in excess of Mach 2 on the little-known French Nord 1500 Griffon fighter prototype). However, the integration of inlet/cowl geometry, inlet placement, and duct length—coupled with the high thrust-to-weight ratio—offered the potential of a simple, lightweight, low-cost inlet that was stall-free throughout the flight/maneuver envelope and had sufficient pressure recovery for a maximum speed of Mach 2.0.

A single, bottom-located, normal shock inlet was simpler, less costly, and significantly lower in weight and drag and resulted in higher overall maneuver potential than other inlet types. It was shielded by the fuselage forebody during extreme maneuvers and was free from asymmetrical flow-field anomalies often encountered in sideslip with side-inlet/bifurcated configurations. The fuselage shielding lowered the flow angularity at the inlet, which in turn allowed more of the maneuver potential of the airplane to be truly usable. At a 25-degree angle of attack, the local flow into a bottom-shielded inlet was approximately 10 degrees, whereas the flow into a side inlet would be as high as 35 degrees. Although side inlets could be made to work adequately, they represented a more complex problem and a higher technical risk.

A bottom inlet did not necessarily present a foreign object damage (FOD) problem. Approximately 12% of all FOD is induced by the nose wheel. The remainder either is personnel-induced or is unrelated to inlet position/location. On the YF-16, the nose wheel location aft of the inlet face eliminated the prime category of FOD. Although inlet suction while static (zero forward velocity) could induce FOD, the height of the inlet lower lip off the ground as a function of equivalent inlet diameter minimized such ingestion. The YF-16 inlet was 10 inches higher off the ground than a Boeing 737 inlet or the inboard nacelles of a Boeing 707, each of which was relatively free of FOD.

A comparison of the wind tunnel tests conducted to evaluate a single bottom inlet versus the more conventional dual side inlets showed another reason for the selection of the former. The drag of the bottom inlet was 6% lower at cruise and 21% lower at the Mach 0.80 maneuver condition.

(8) increased "g" cockpit: A specially tailored cockpit provided the necessary man-machine interfaces for "head-up, hands-on" flight control and weapon delivery with unrestricted visibility and improved "g" tolerance. The crew station was configured so that the pilot can engage in air combat without removing his hands from the throttle and controller or his eyes from the target. In addition, he could perform his tracking and control functions effectively in high-g combat.

Indications from current research are that a 65-degree seat back angle may be optimum for a 9 to 10 g fighter. However, pending the completion of this research, the 30-degree reclined position with a raised heel-rest line was selected because it afforded a reasonable improvement in pilot tolerance level and tracking error while still retaining conventional and proven cockpit instruments, equipment, escape seat, and arrangement criteria.

The fly-by-wire technology/application permitted the use of a minimum-displacement force sensing stick (pilot's "side stick" controller), located above the right console. This configuration allowed more precise pilot inputs and minimized the possibility of inadvertent inputs and feedbacks, which were particularly critical during high-g maneuvers in the vertical and lateral directions.

Completely unobstructed visibility in the principal search area was provided by a one-piece windshield/canopy. A polycarbonate bubble canopy provided 360-degree upper-hemisphere vision, with a minimum of 15 degrees over the nose, 40 degrees down at the 90-degree azimuth, and excellent aft vision to cover the "6 o'clock" direction. A 30 degree average slope of the windshield provided superior optical quality, with a maximum distortion equal to a 1-in-20-grid slope. Although the "full bubble" represented a rather significant supersonic drag penalty, it was not inconsistent with "eyeball-to-eyeball" combat and the high-maneuver capability of the airplane in the combat arena.

The avionics, cockpit, and armament subsystems were fully integrated to minimize pilot workload during all phases of weapon delivery. Critical fire control functions (gun/missile override, radar control, weapons release) were located on the throttle and flight controller grips to provide quick-reaction, fingertip control of weapons and displays during all maneuvering conditions.

Each of these advanced technologies, when integrated with the others, made a direct and relevant contribution to the specified mission and combat performance. Together these technology/design innovations produced the equivalent of a 10% reduction in airframe weight, which resulted in both lower cost and 12% reduction in mission weight as well as increased performance through increased thrust-to-weight and lower drag (lower drag in terms of total pounds of drag). The cumulative benefits of these integrated technologies yielded a reduction in mission weight of 4,420 pounds (2,325 pounds in airframe weight and 2,095 pounds in fuel weight). At $350 per pound, this meant at least $800,000 lower airframe cost.

The integrated technologies represented the very latest fighter technologies available for a transonic-supersonic fighter. The YF-16 prototype was the first production-feasible fighter to fly with any of these technologies incorporated as part of the original design. As such, it provided the maximum pilot-machine capability available.

Following signing of the official contract on April 13, 1972 (which also called for some 12 months of flight testing), construction of the two prototype YF-16's was initiated. The aircraft were some 21 months in the construction stage (this being an exceptionally short gestation period for a high-performance advanced technology aircraft) and official taxi-out ceremonies with the #1 aircraft (72-1567) took place on December 13, 1973, at General Dynamics massive Fort Worth, Texas production facility (Air Force Plant 4).

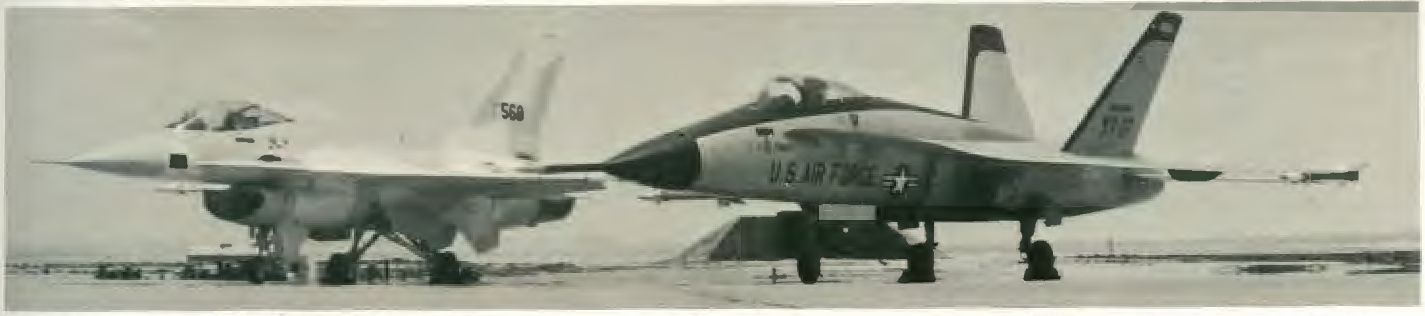
At the time of F-16 contract signing, costs of a production program were broken down as follows (based on a Fiscal 1972 buy of 300 aircraft at a rate of 100 aircraft per year):

| | |
|---|---|
| Airframe | $1,570,000 |
| Propulsion | 940,000 |
| Electronics | 200,000 |
| Armament | 50,000 |
| Unit ECO | 160,000 |
| Unit recurring flyaway | $2,920,000 |
| Total recurring flyaway | $876,000,000 |
| Non recurring flyaway (tooling) | 26,000,000 |
| Flyaway cost (300 aircraft) | $902,000,000 |
| Unit flyaway | $3,010,000 |
| Support (ground & training equipment, etc.) | $105,100,000 |
| Weapons (excluding prototype program costs and any RDT&E costs) | $1,007,000,000 |
| Unit weapons system cost | $3,360,000 |

It is interesting to note that the prototype contract was fulfilled with a profit to General Dynamics of $2,000,000.

# CHAPTER 7

# THE NORTHROP COMPETITION AND THE FLY-OFF



*Two of the four lightweight fighter competition prototypes sit on the ramp at Edwards AFB in 1974, near the end of the fly-off. On the left is the number two YF-16, 72-1568, and on the right is the number one YF-17, 72-1569. General Dynamics*

Following contract signing in April of 1972, the Northrop Corporation initiated construction of their twin-engine YF-17 lightweight fighter prototype. Gestation of this airplane was somewhat longer than that of the competing YF-16, due in part to its somewhat greater complexity and in part to delays in getting its GE YJ101 engines approved for flight operations. Accordingly, the first prototype (72-1569) wasn't rolled out of Northrop's Hawthorne, California facility until April 4, 1974.

The YF-17's design features optimized to meet the demands for high energy levels, good maneuvering characteristics, excellent stall-post-stall characteristics, and turning capability in the air battle arena, were as follows: maneuvering flaps, large leading edge extensions, twin tails for directional stability, cockpit design for increased load factor tolerance, and a wing/engine inlet integrated to allow the engines to perform under the most difficult conditions of low airspeed, high altitude and large yaw rates and high pitch angles. The basic wing planform was tailored to provide good flying qualities and a high degree of spin resistance. The planform was combined with the large leading edge extension (strake) which gave a remarkable increase in the maximum lift coefficient and reduced buffet intensity and decreased the drag encountered at supersonic speeds and during high maneuvering situations. The leading edge extension approximately doubled the lift co-efficient of the basic wing. The maneuvering flaps provided an additional increment of lift above the leading edge extension and basic wing planform.

The YF-17 also incorporated a rather unique feature known as differential area ruling. Normally, fuselage area ruling is performed to obtain higher transonic acceleration rates. However, for this aircraft it was felt that differential area ruling was desired for the upper and lower fuselage areas to optimize the supersonic turning capability. The combination of all of these design features resulted in improved turn rates.

The twin vertical tails were canted slightly outboard. This feature provided the high degree of directional stability required during the dynamic maneuvers expected from this type of aircraft. With the twin tails, one vertical was expected always to be in the free stream air to provide directional stability regardless of the angle-of-attack and sideslip magnitude.

The YF-17 was powered by two General Electric YJ101 two-shaft augmented turbojet engines rated at approximately 15,000 pounds thrust each. Born as the GE15, this engine would eventually enter production (for the F-18) as the F404.

A considerable amount of preflight phase testing was accomplished in the YF-17 program prior to the actual inflight program initiation. The facilities utilized to accomplish this testing were the large amplitude flight simulator located at Northrop's Hawthorne, California production plant, the spin and free flight test tunnels at Langley and the Cal-Span variable stability T-33 aircraft.

Wind tunnel development activities related to the YF-17 extended over a period of eight years and amounted to 9,700 hours total time. Significant features developed in the wind tunnel were the hybrid wing and the engine/airframe integration, as well as the positioning of the vertical and horizontal stabilizers for optimal high angle-of-attack performance.

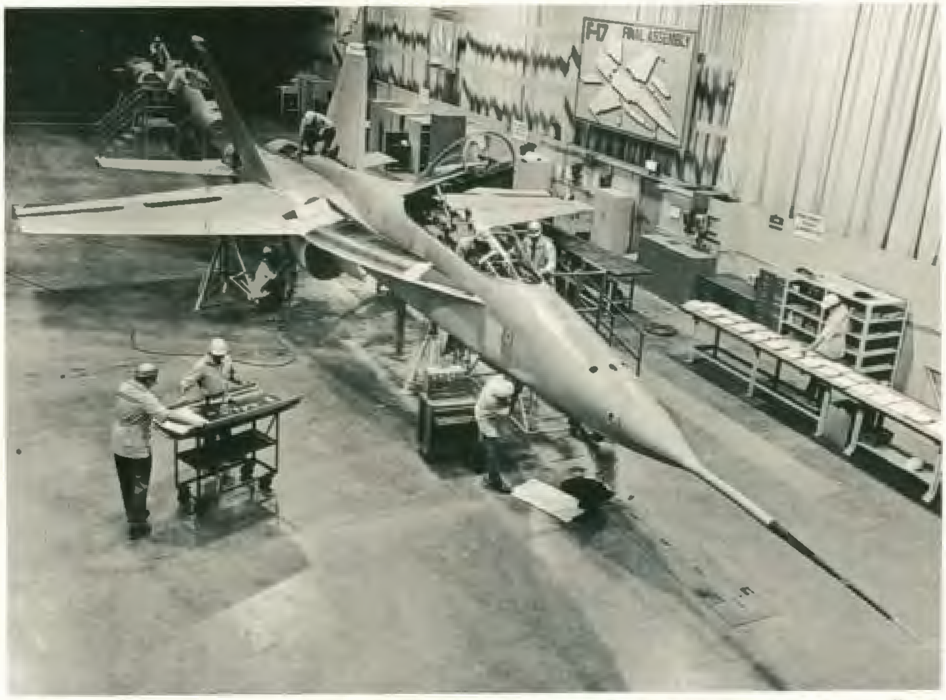
The stall-post-stall wind tunnel results indicated a stable, controllable aircraft in angles-of-attack as high as 45 degrees and recovery from spins that could be accomplished with normal controls—even from the flat spin mode.

The large amplitude flight simulator was utilized to investigate flying qualities in the normal and failure modes of the flight control system, to develop tracking capabilities and criteria, and to explore stall-post-stall aircraft characteristics. During the accomplishment of these investigations the USAF lightweight fighter test team pilots from the AFFTC and the Tactical Air Command participated in all of the evaluation activities that were conducted.

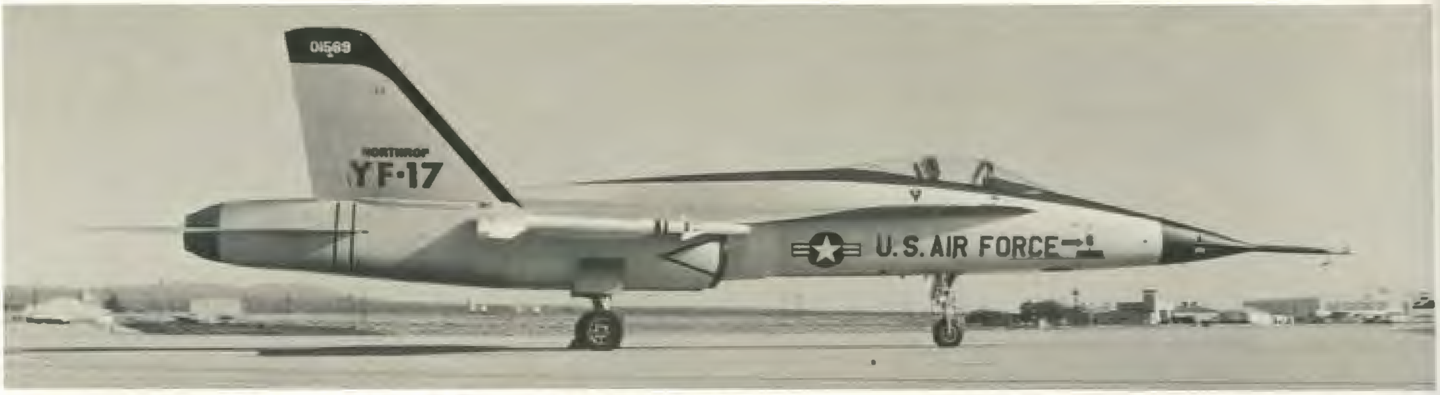
All test force pilots including the contractor pilots flew the variable stability T-33 which allowed the real world assessment of approach conditions and selected-point-in-the-sky type evaluations.

The initial airborne testing of the YF-17 began with the first flight (lasting 61 minutes) of the #1 airplane on June 9, 1974 (this, incidentally, was also the first flight test of the GE YJ101), at Edwards AFB, California. As the program progressed from one of pure evaluation to one of competitive aircraft selection, the flight test program was prioritized to define the areas where inflight data was required to support a decision related to aircraft choice.

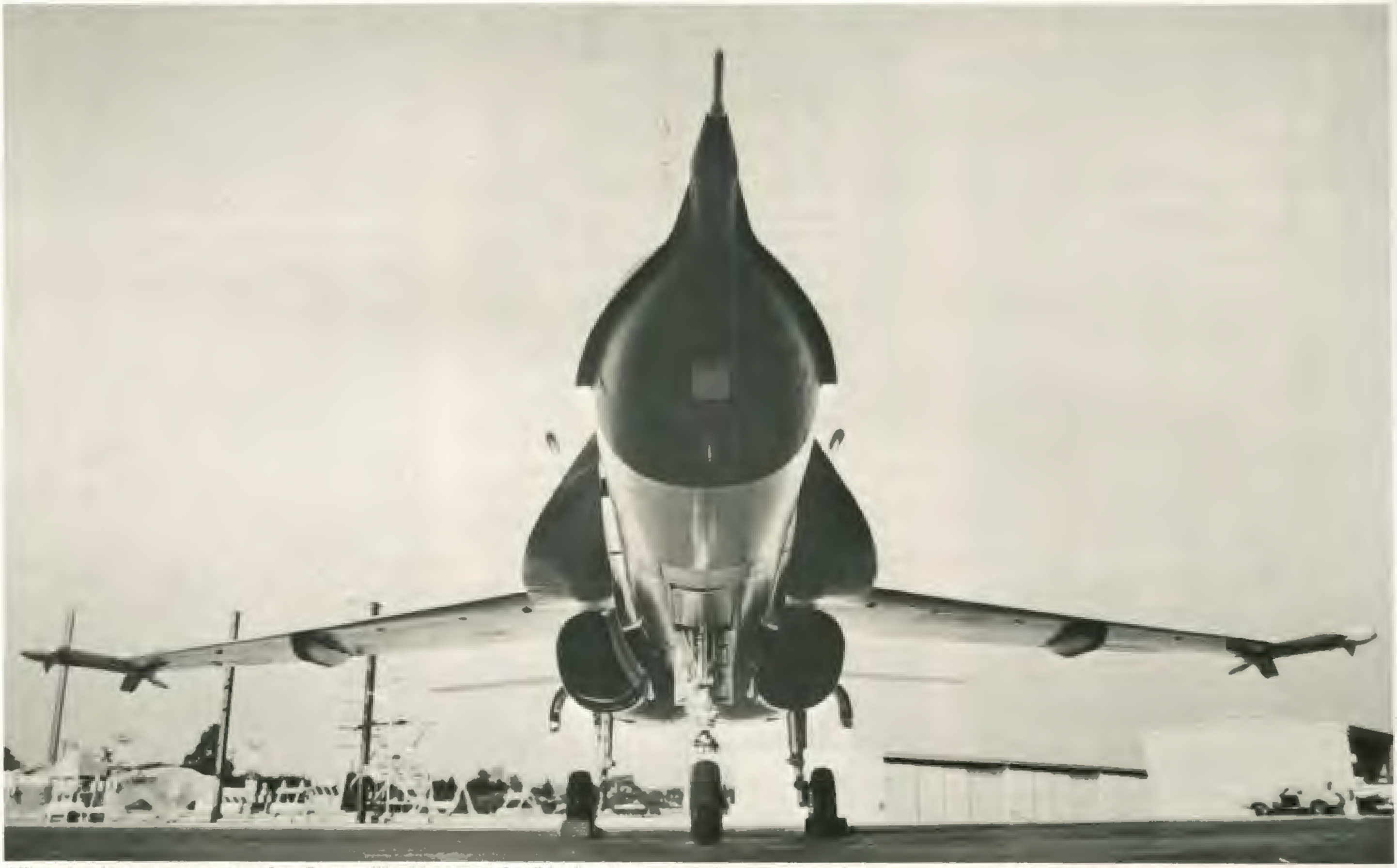
On August 21, 1974, the second prototype



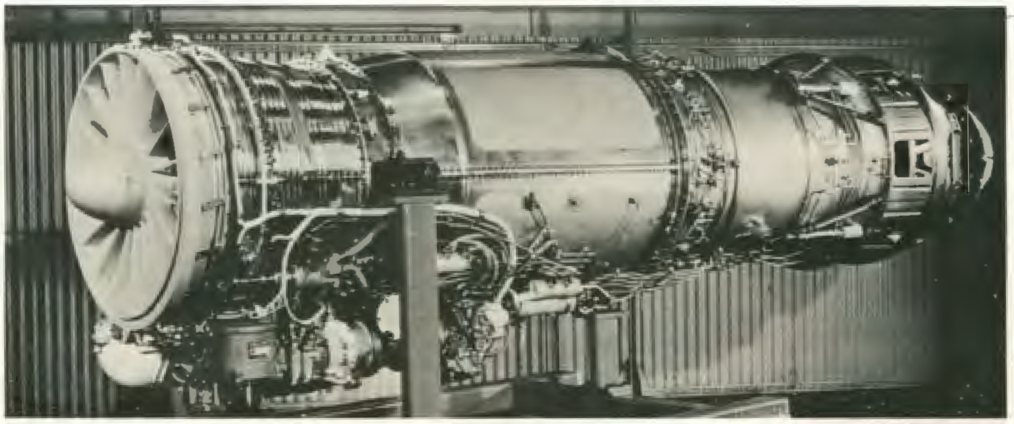
*The number one YF-17, mounted on support stanchions, is seen at Northrop during final assembly. Visible on nose are sensing ports for flight instrumentation, the special extended nose boom for test instrumentation, and the composite construction wing root extension. Northrop Corporation*



*The YF-17 presented an interesting albeit complex convergence of lines and symmetry. Twin vertical fins provided exceptional vertical surface area and the view from the cockpit was quite good. Landing gear was from stock F-5 components. Northrop Corporation*



*Wing leading edge extension is readily apparent in this front view of the YF-17. The extension was intended to significantly increase lift, reduce drag, and improve handling qualities. NASA tunnel tests of the YF-17 revealed good handling to 45-degree angles of attack. Northrop Corporation*



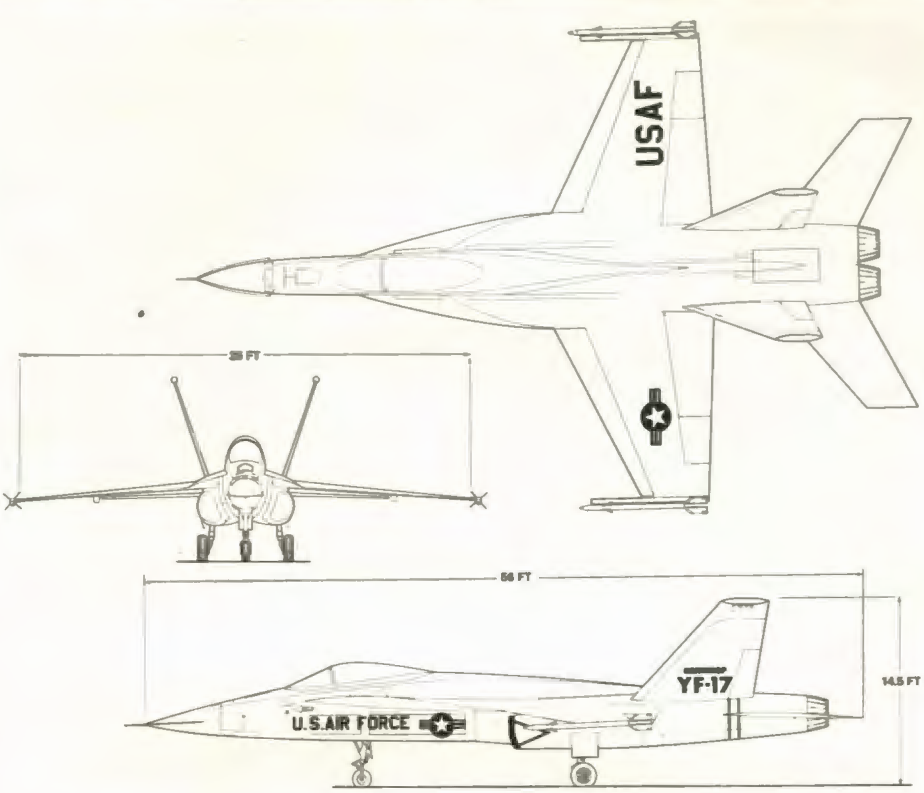
*The YF-17 prototypes were powered by two advanced technology General Electric YJ101 afterburning turbojet engines rated at 15,000+ pounds thrust each. These engines gave the airplane a thrust to weight ratio of about 1.25 to 1. The YJ101 completed its USAF Prototype Preliminary Flight Rating Test (PPFRT) 18 months after the engine's first test run in July of 1972. Northrop Corporation*

YF-17, 72-1570, made its first flight.

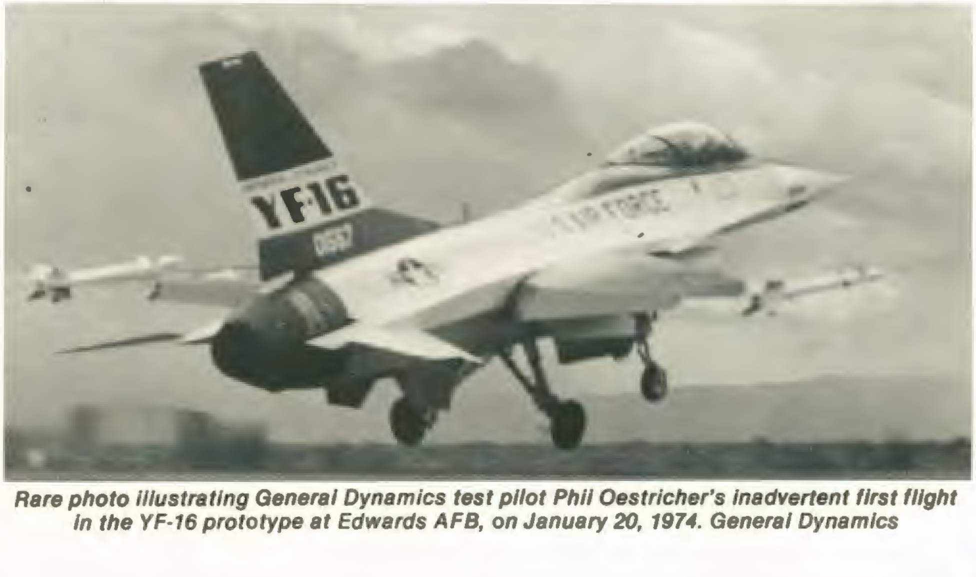
The prototype YF-16, following its delivery flight from Fort Worth to Edwards AFB on January 8, 1974, aboard a Lockheed C-5A, had, in the meantime, been reassembled and prepared for initiation of its flight test program. General Dynamics YF-16 project test pilot, Phil Oestricher, was assigned preliminary flight test duties. High-speed taxi tests got underway on January 20th. During one of these tests, an unexpected first flight inadvertently took place.

What follows is Oestricher's flight report describing the events of January 20th:

> "The purpose of this series of tests was to perform a limited functional check of various systems (including the instrumentation system and test control at Bldg. 3940 and the trailer) and to determine the taxi characteristics at various speeds.
>
> "The test configuration was that of the basic airplane with an AIM-9 missile mounted on each wingtip. The airplane was fully fueled at the start of the tests and was flight ready in all respects.
>
> "Taxiing at normal speeds was evaluated while moving the airplane to the "last chance" check area for runway 22. Periodic application of brakes was required to prevent an excessive speed buildup. The braking effort expended by the pilot (product of pedal force and duration of pedal displacement) was perhaps 30% to 50% more than required in the case of a fully fueled, clean configured RF-4C. Nose wheel steering was used throughout the run and proved to be precise and easily controlled.
>
> "Following a check by the mobile crew, the airplane was positioned on runway 22 for an idle power taxi run without brake restraint. A taxi speed of around 30 knots was noted during this test. After a period of straight ahead taxiing, several S-turns were made with no difficulty. The airplane was stopped after traversing about 5,000 feet.
>
> "Following an inspection by the mobile crew, the airplane was accelerated toward a target speed of 80 knots. It is believed that an overshoot of about 10 knots occurred on this run. The nose wheel steering appeared to be overly sensitive at speeds of 50 knots or higher and was accordingly disengaged. Directional control by rudder was very satisfactory after the NWS disengagement. The airplane was stopped using moderate brake pedal force after travelling about 5,000 feet. It was then towed back to the "last chance" check area for runway 22 for brake cooling.
>
> "The brakes were checked and found to have cooled sufficiently to resume taxi tests. A normal start was accomplished as were the pre-takeoff check list items. The IIRS was aligned and checked for proper operation. The airplane was positioned on runway 22 for the planned 135 knot high speed taxi run. The brakes were held and the power lever slowly advanced to determine the RPM at which wheel slide would occur. This was determined to be about 87% rpm. The gross weight at this time was about 21,200 pounds. The corresponding C.G. was 34.3% M.A.C. The engine was kept at idle RPM until the runway winds (as reported by the tower) dropped below the 12 knot maximum agreed to for the taxi run. Upon tower clearance for the run, the brakes were released and intermediate power selected for a period of about six seconds after which a substantial power reduction was made. Nose wheel steering was disengaged at an estimated 50 knots. At about 130 knots (but apparently with the airplane still accelerating somewhat) the airplane rotated to about 10 degrees angle of attack and small lateral stick inputs were made in an attempt to get a feel for control response. No response was noted by the pilot (doubtless because the main gear was still restraining the airplane from rolling) and the angle of attack was intentionally increased a small amount. The airplane had continued to accelerate during this time but the pilot was unaware of the fact. Immediately upon rotating the second time the airplane lifted off with the left wing dropping rather rapidly. Right roll command was applied and the airplane was immediately involved in a fairly high frequency pilot induced oscillation (10 cycles in 14.3 seconds). Eventually the roll oscillation was stopped but not before lightly touching the rolleron wheel on the lower outboard fin of the left AIM-9 to the runway, striking the right horizontal tail tip (at the trailing edge) on the runway, bouncing off of the main landing gear several times in a nose-high and generally symmetrical manner and developing a substantial heading deviation from the runway axis.
>
> "The latter factor prompted the decision to fly out of the situation as it was felt that it would be impossible to steer



*Three-view drawing of YF-17 with pertinent dimensions. Northop Corporation*



*Rare photo illustrating General Dynamics test pilot Phil Oestricher's inadvertent first flight in the YF-16 prototype at Edwards AFB, on January 20, 1974. General Dynamics* the airplane so as to remain on the runway even if the nose wheel could be quickly brought down to the surface. Intermediate power was applied for a short period of time after which a fairly low thrust level was held. The airplane was allowed to slowly climb away in a shallow left turn, with a minimum of pilot control inputs being made. A downwind leg to runway 22 was established at about 600 feet AGL at 175 KIAS. The ADC caution light was noted to be on at this time. No attempt was made to turn the light out by resetting. A wide pattern was flown to a long, decelerating final approach with 12-degrees angle-of-attack being established just prior to touchdown. A very slight (low amplitude and frequency) lateral motion was noted prior to touchdown. The ground effect was quite pronounced and the engine was brought to idle while still airborne. Aft stick force was relaxed after touchdown and the nose wheel fell gently to the runway at which time the speed brakes were commanded open. It should be noted that the pitch trim was still in the neutral position at landing since no pilot trim had been applied during the flight. Moderate braking was applied until the airplane was stopped. Following an inspection by the mobile crew, the engine was shut down and the airplane was towed to the hangar.

"The tactics attempted during the pilot induced oscillation are evident from watching the excellent movie films available. Briefly the attempt was to:

1. Keep the wingtips off of the runway and stop the roll oscillation with the wings level.

2. Recover from the nose high attitude when the lateral control problem had been solved.

3. Control altitude and vertical velocity with thrust. It is believed that this particular attempt was relatively successful.

"No sideslip was noted by the pilot at any time despite the violent nature of the oscillation and the full lateral commands being applied. The roll control problem appeared to be the most serious by far and accounted for most of the pilot's attention at the time. Once away from the ground and the need to keep roll angle within tight bounds, the pilot was able to relax with the results which are evident in the movie film. The pattern and landing were understandably somewhat conservative although a small rudder doublet was performed during the final portion of the approach in an attempt to assess directional control sensitivity. No dihedral effect was noted and the airplane felt somewhat sensitive compared to other tactical airplanes.

"Takeoff and landing gross weight/C.G. combinations were 21,100 lbs./34.3% M.A.C. and 20,000 lbs/35.0% M.A.C., respectively."

Post flight evaluation uncovered the fact that Oestricher had discovered that the combined flaperon and slab stabilator (rolling tail) roll gain control was significantly more sensitive to stick input than necessary. This sensitivity had led to severe roll control oscillations during the high speed taxi run and though these were quickly brought under control, Oestricher discovered that the airplane had turned somewhat and was now heading off the side of the runway and into the desert sand. Accordingly, he elected to takeoff rather than risk damaging the aircraft landing gear or worse, completely losing the airplane. At the time of this decision, the YF-16 was moving at 142 kts. and was in a critical nose-high attitude.

Replacement of the stabilator consumed several days and following an additional week in fly-by-wire gain control analysis and test, the airplane was once again cleared for flight. Corrections incorporated included manually reducing the gain to 50% for takeoff and then manually restoring it to 100% once the aircraft was in the clean (cruise) configuration (this was later to be made a standard feature of all production F-16's—though it would be fully automated and would not require manual input).

The first official flight, again with Oestricher at the controls, finally took place on February 2nd. Lasting some 90 minutes, the flight permitted the airplane to be flown through a modest test routine that included wind up turns to 3g at 350 kts and 30,000 feet. The flight was concluded successfully and without incident and Oestricher expressed exceptional pleasure with the airplane's performance.

Exploration and expansion of the #1 YF-16's flight envelope was rapidly undertaken following successful completion of the airplane's first flight. On the third flight, taking place on February 5th, Oestricher exceeded Mach 1 for the first time, and on the twentieth flight, occurring on March 11th, Mach 2 (at 40,000') was reached and exceeded (*Aviation Week & Space Technology* reported that 1,400 mph had been achieved). During the course of these same early missions, the airplane also achieved a maneuvering load high of 7.3 g in high-speed wind-up turns.

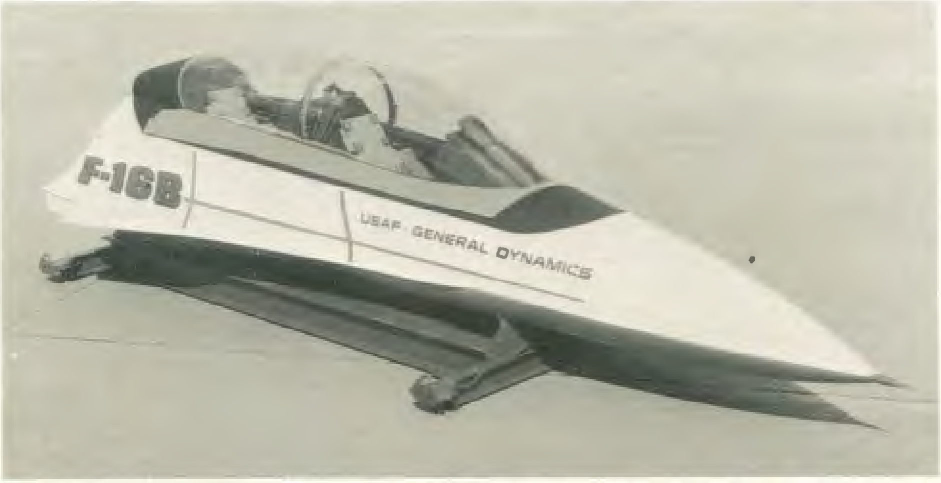
Shortly after the Mach 2 flight, the YF-16 experienced the first of several inflight engine power losses later attributed to a problem with fuel contamination. Contamination was found to cause a valve to drive the fuel control unit to idle. Corrections to the Bendix built fuel control unit involved the inclusion of eight additional fuel screens, and this, coupled with a correction for a lack of tolerance to high fuel temperatures (normally caused by extended ground operation), apparently solved the problem.

The second YF-16 (72-1568) was now cleared for flight test following its delivery to Edwards AFB by C-5A on February 27th, and on May 9, 1974, with General Dynamics company test pilot Neil Anderson at the controls, it took to the air for the first time.

The two prototypes were quite similar in almost every respect, differing primarily in their respective paint schemes. The #1 airplane sported a bright, high-visibility (and highly patriotic) red, white, and blue scheme; and the #2 airplane sported a General Dynamics-generated camouflage scheme of air superiority blue broken up by random areas of cloud (off-) white.

The fly-off competition between the YF-17 prototypes and the YF-16 prototypes officially got underway at the time of the respective first flights of each #1 aircraft. Comparisons were primarily paper in nature throughout the fly-off and because of exceptional political circumstances and the undisguised Air Force dislike of the entire lightweight fighter program (which they considered to be a direct and very serious

***Special forward fuselage section of single seat F-16 used for sled runs during ejection seat tests. General Dynamics***



***Special forward fuselage section of two-seat F-16B was also built for ejection seat test sled runs. General Dynamics***

threat to the F-15), the aircraft were never actually flown against each other.

During the fly-off, the two YF-17's logged a total of 268 flights totalling 324 hours and 7 minutes, of which 12 hours and 43 minutes were at supersonic speed. During these tests, the airplanes were flown against other operational Air Force fighters (and, rumor has it, against a captured MiG-17 and a MiG-21) and used in a variety of weapons tests including bomb delivery, air-to-air gunnery, and missile launch.

The two YF-16's were similarly occupied during the fly-off, reaching altitudes in excess of 60,000 feet, achieving maneuvering g forces of 9, and accelerating to speeds in excess of Mach 2 on several occasions. Additionally, subsonic and supersonic AIM-9 launches were conducted, 12,948 rounds of 20mm ammunition were fired, and 10 Mk.84 2,000 pound bombs were dropped. Maximum endurance achieved during these test flights was 2 hours and 55 minutes without refueling (one flight, with inflight refueling, lasted 4 hours and 25 minutes).

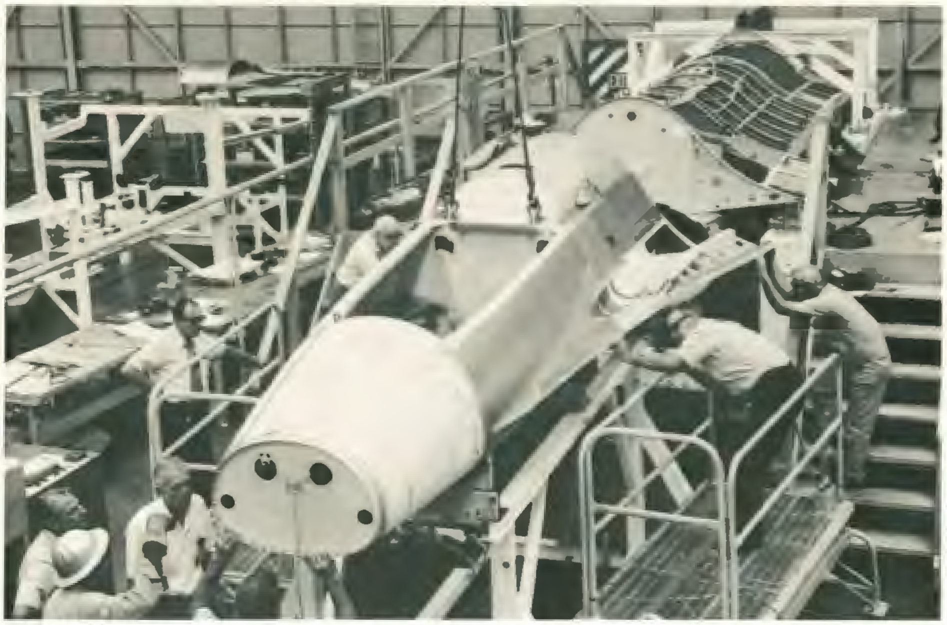
A total of 330 missions were logged, these amounting to 417 hours of flight time including 13 hours and 15 minutes at supersonic speeds. Thirteen flights had been logged in February, 28 in March, 43 in April, 63 in May, 102 in June, 142 in July, and 195 in August. During this period, 6 pilots (approximately 25 would eventually be assigned, including pilots from the Air Force Flight Test Center, the Tactical Air Command, the Air Force Test and Evaluation Center, the NATO, and General Dynamics) checked out in the aircraft, flutter clearance was obtained out to 2,150 pounds per square foot dynamic pressure, 20 gun firing missions were flown, the 370 gallon external tanks were cleared to .9 Mach and 4g, maximum weight takeoff's were demonstrated, 3 spin chute deployments took place, and 11 aerial refueling missions were flown.

In a test to verify the ability of the F-16 to meet mission requirements specified for a potential Navy contract (and potential foreign sales to such countries as Canada and Iran), the #2 airplane was modified to carry two AIM-7 *Sparrow* radar-guided air-to-air missiles. A number of pylon locations were tested including the wing tips, the wing pylons, and a rather unusual mounting on the main landing gear well doors. On October 6, 1977, the first of several AIM-7 launches was conducted over the weapons test range at Edwards AFB (in November of 1978, a British *Skyflash*, similar in most respects to the AIM-7, was also launched from a YF-16).

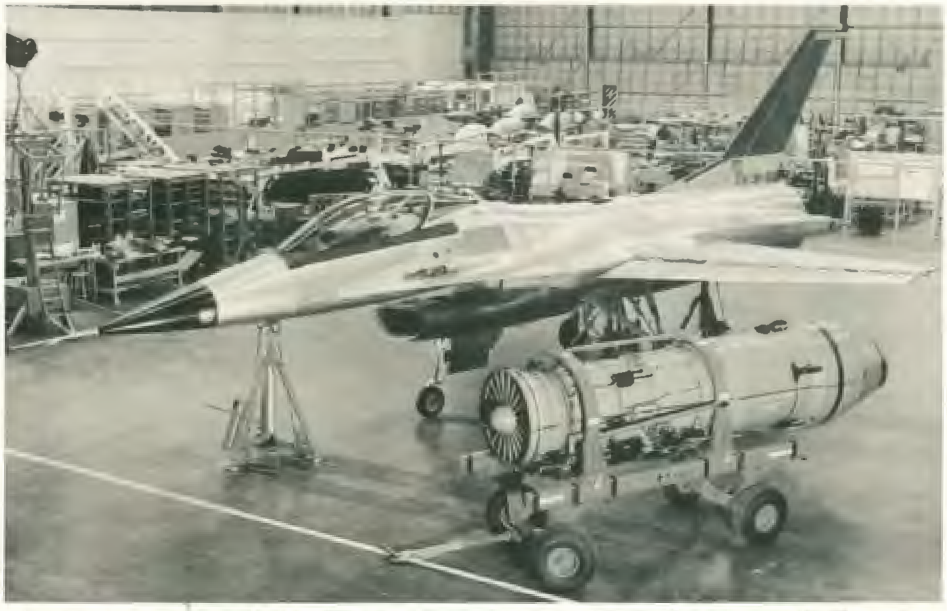
By the time the fly-off was over, a relatively large number of pilots had flown both aircraft types. Company and Air Force test pilots had logged the majority of hours, with Navy and miscellaneous government pilots logging the rest. Inputs from these professionals played a key role in the final decision making process.

As a point of interest, it should be noted that most of the military pilots assigned to the fly-off program were given an opportunity to fly both the YF-16 and the YF-17—and usually more than once. Additionally, following the air-to-air combat sessions, the adversary pilots were asked to critique the two designs in terms of their competitiveness. Adversary aircraft flown against the YF-16's and YF-17's included the Cessna A-37B, the McDonnell F-4E, the Convair F-106, the MiG-17, and the MiG-21 (other Soviet-built fighters are said to have participated, but this has yet to be verified).

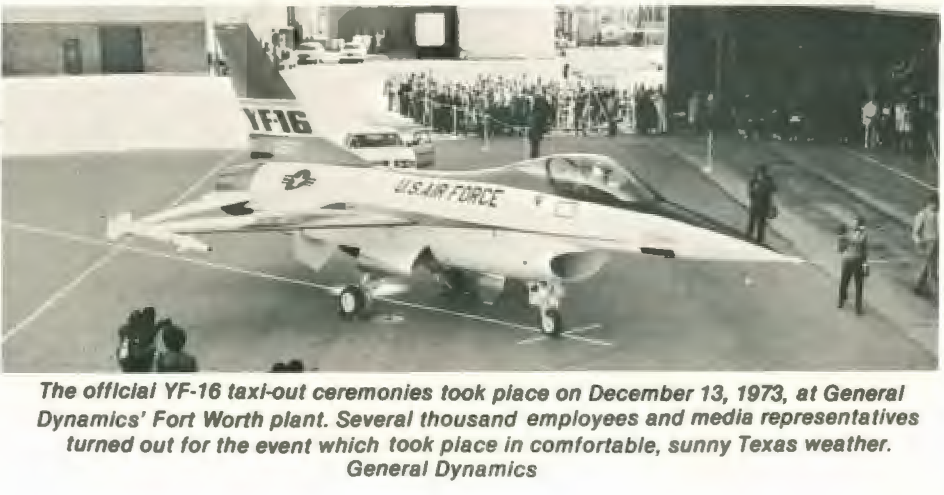
The last missions of the competition took



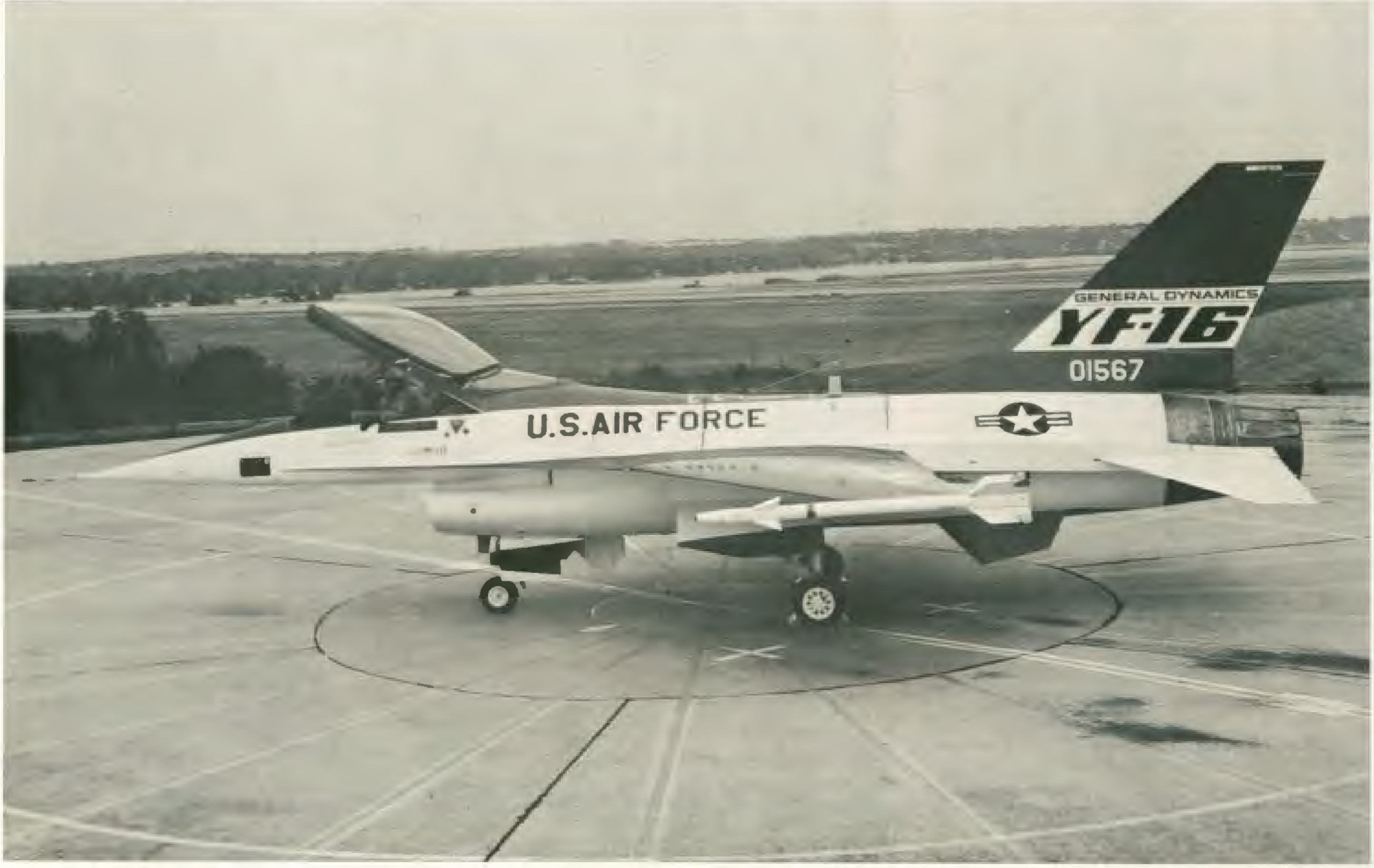
*Number one YF-16 fuselage is seen during mating of forward and aft sections at General Dynamics in June of 1973. These were the first major airframe components to be joined. General Dynamics*

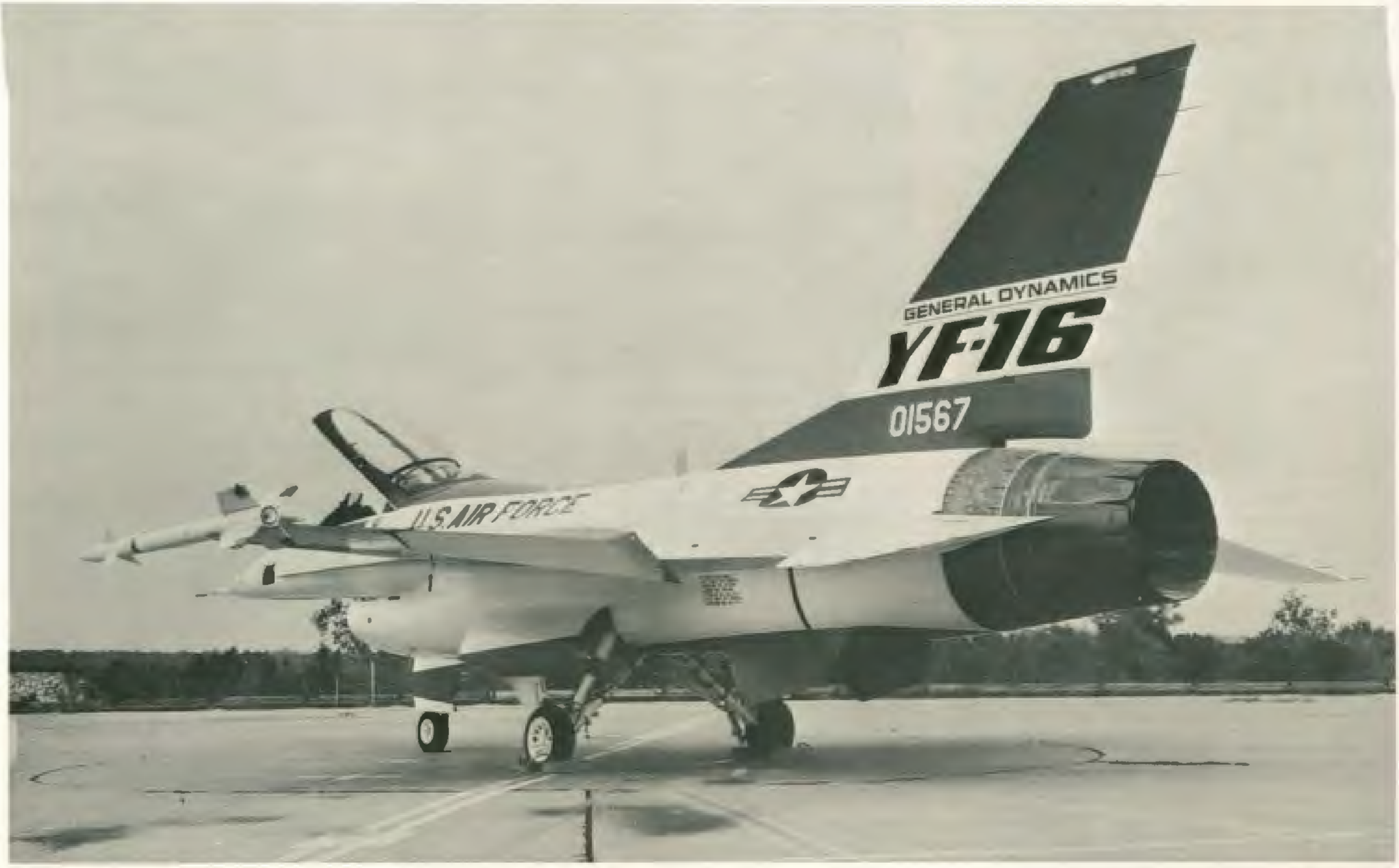


*Nearing completion, the number one YF-16 sits alongside Pratt & Whitney F100 mock-up inside "special projects section" hangar at General Dynamics. Actual engine installation had not taken place at the time and the horizontal tail surfaces, rudder, and ejection seat were also missing. General Dynamics*



*The official YF-16 taxi-out ceremonies took place on December 13, 1973, at General Dynamics' Fort Worth plant. Several thousand employees and media representatives turned out for the event which took place in comfortable, sunny Texas weather. General Dynamics*





*Four views of the number one YF-16 in its patriotic red, white, and blue markings taken prior to the official roll-out ceremonies. Company test pilot Neil Anderson sat in the cockpit as the airplane was photographed on the compass rose next to the General Dynamics plant.*
*General Dynamics photo*

USAF
U.S. AIR FORCE

place in mid-December, 1974, and the following several weeks were spent in completing analysis of gathered data and pilot input. Finally, on January 13, 1975, Secretary of the Air Force John McLucas made the announcement—the General Dynamics YF-16 had been picked as the lightweight fighter (Air Combat Fighter) competition winner based on the program's two primary criteria, performance and cost. Importantly, the airplane had also been an almost unanimous choice of the fly-off competition pilots. Contracts were awarded to General Dynamics ($417,900,000) and Pratt & Whitney ($55,500,000) for fifteen F-16 engineering and development aircraft and their F100 powerplants. Subsequently, on April 9th, this contract was modified to cover the costs of only eight aircraft: six single-seat F-16A's and two two-seat F-16B's. Construction was scheduled to begin at General Dynamics awesome 6,500,000 square foot plant in Fort Worth, Texas in July of 1975.

The loss was a significant set-back for Northrop, though one not totally unexpected. The company had been somewhat dissatisfied from the first with the way the fly-off had been conducted and in fact, had raised serious doubts about several important judging criteria. According to several General Dynamics officials, the results would almost certainly have been in favor of Northrop if the lightweight fighter competition had remained a paper exercise rather than a hardware exercise.

The reasons for this were:

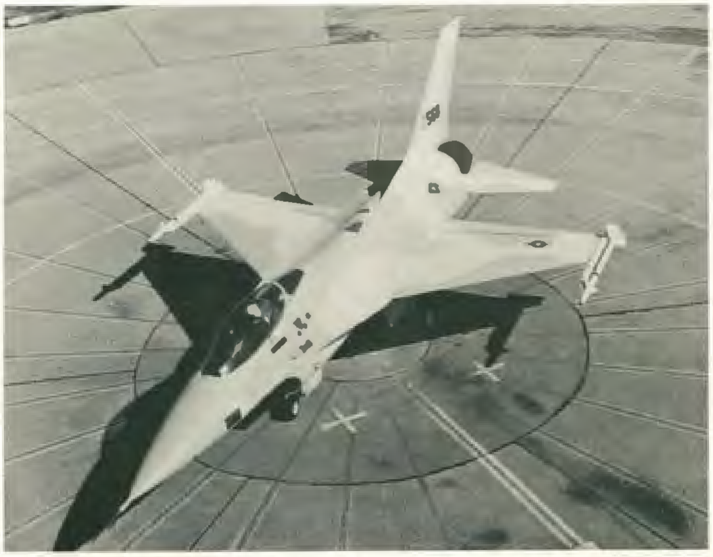
(1) Northrop had proposed a bigger airplane and it is likely that the "bigger airplanes have more capability" syndrome would have prevailed.

(2) Northrop's airplane, though appearing more expensive, was claimed actually to cost less. And Northrop's reputation for building inexpensive aircraft would likely have influenced the decision making process.

(3) The Northrop design was technologically less sophisticated and therefore less of a risk. Conservatism has consistently prevailed in competitions such as this.

Northrop also felt it had operated at a distinct disadvantage due to the fact that the YF-17 had entered the flight test program 4 months later than the YF-16 thus forcing the company to cram all testing into six months rather than ten (NATO was awaiting the final lightweight fighter competition ruling before initiating the final stage of its decision making process—and it had requested that the Air Force make a choice no later than December of 1974); and that the YF-17 was flying with a prototype engine (YJ101) whereas the YF-16's F100 was a proven powerplant with significant logged time.

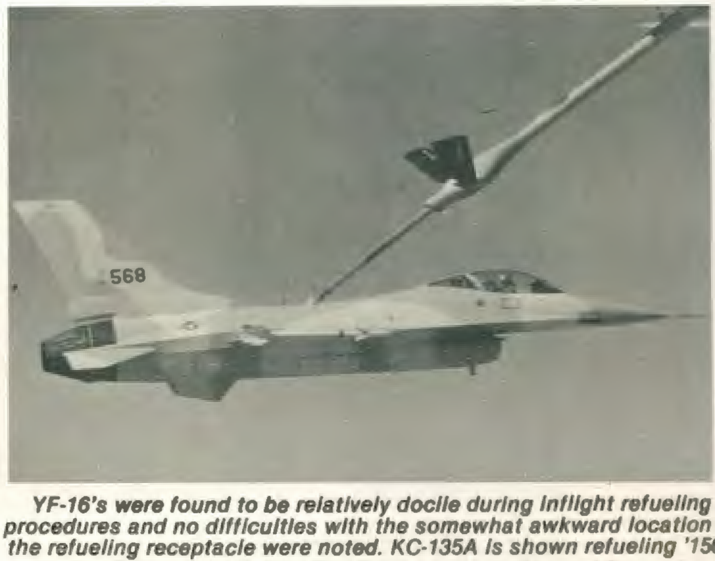
Other factors affecting the Air Force decision included the noteworthy differences in estimated production costs (YF-17 flyaway costs were determined by Air Force estimators to be some $250,000 more than those for the YF-16) and operating costs; the F-16's tremendously superior performance at transonic and supersonic speeds; the F-16's superior maneuverability (its transient maneuverability—of great import in air-to-air combat—was remarkable); the F-16's greater excess thrust; and the F-16's greater range (the lightweight fighter fly-off, in fact, gave General Dynamics its first opportunity to prove, beyond any doubt, that Hillaker's range estimates were not paper doodles—during testing the YF-16 demonstrated range significantly superior to that of the F-15, thus destroying the Air Force's primary argument opposing the lightweight fighter).



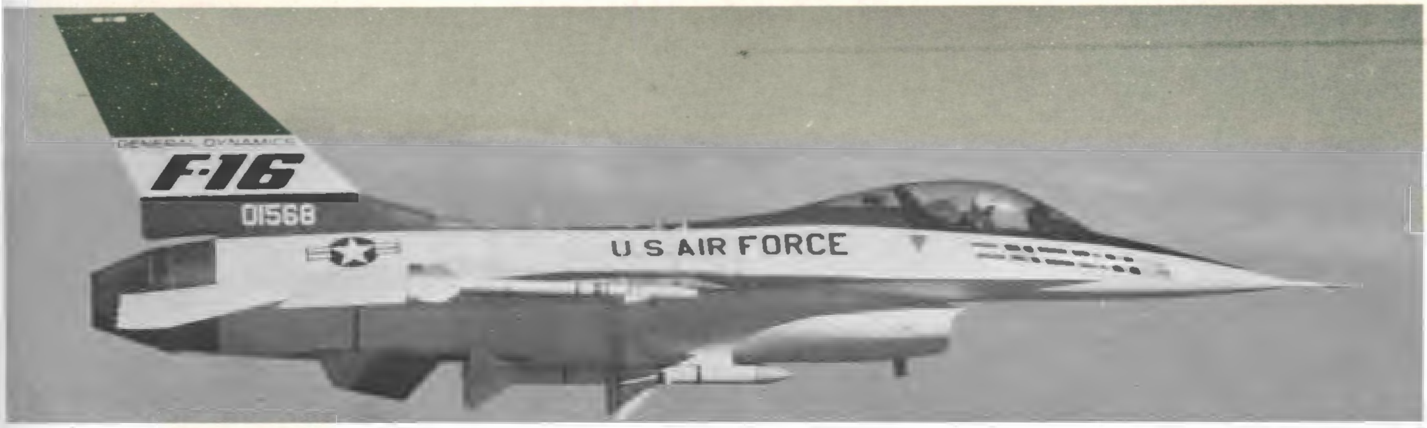
*Following in the footsteps of YF-16 '1567, '1568 is photographed on the compass rose at General Dynamics shortly after its roll-out. Airplane sported an unusual sky-blue and off-white wrap-around camouflage developed in-house at General Dynamics. General Dynamics*

*First flight of '1568 took place from Edwards AFB, on May 9, 1974, with company test pilot Neil Anderson at the controls. General Dynamics*

*Another view of '1568 after roll-out shows the airplane sporting interim 370 gallon drop tanks. General Dynamics*

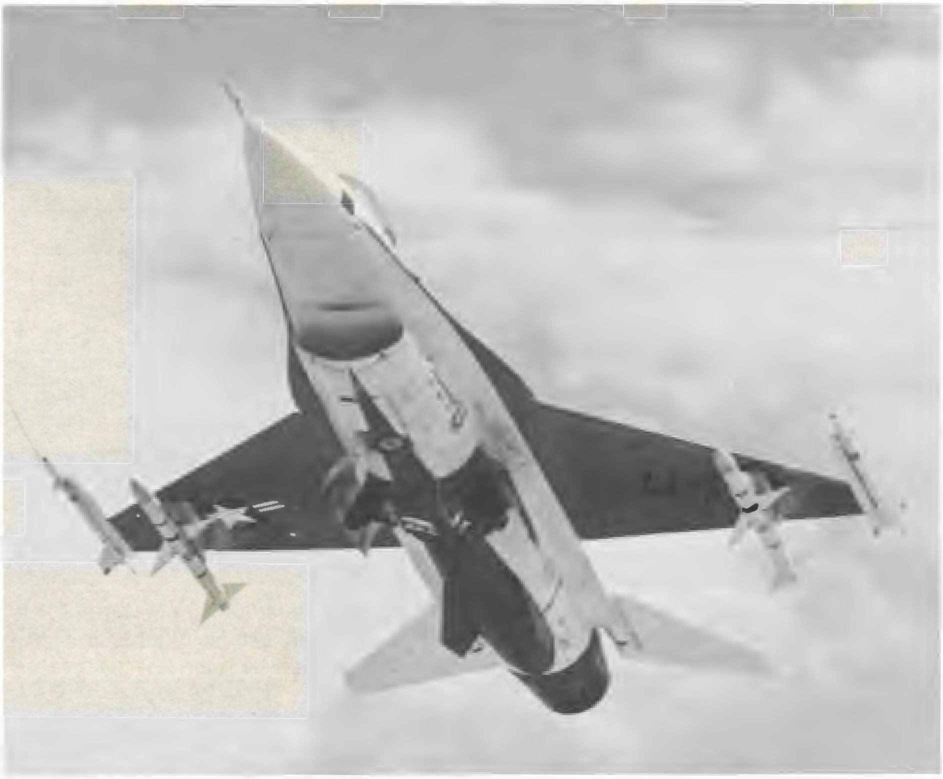


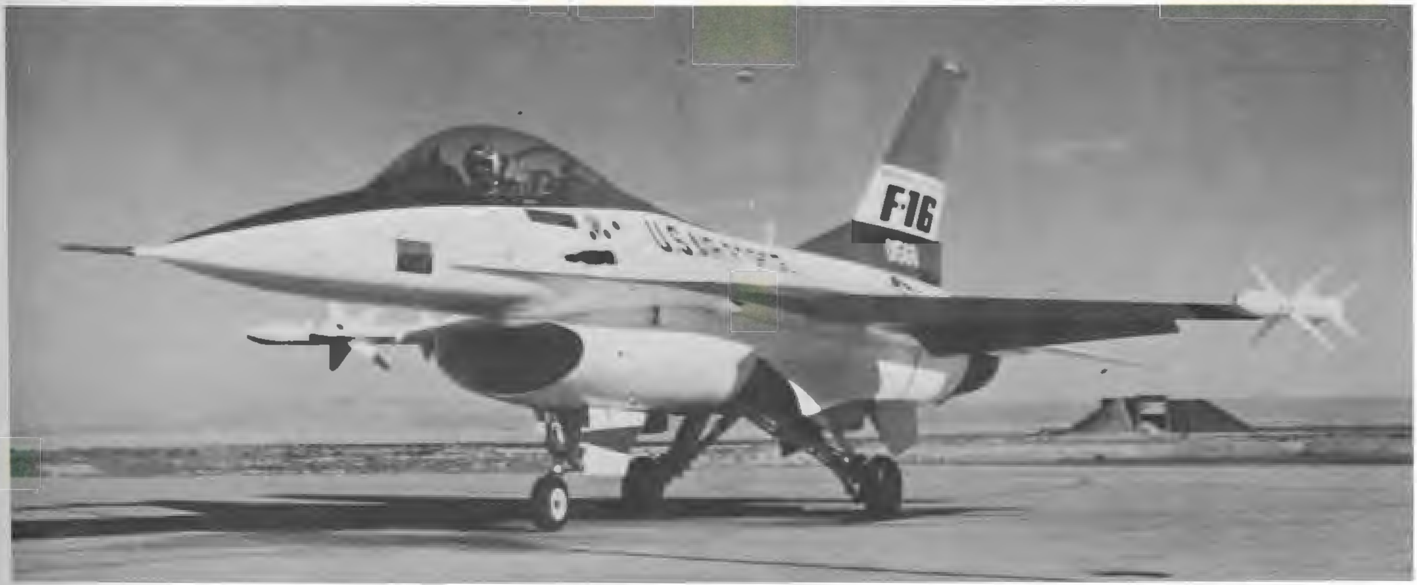
*YF-16's were found to be relatively docile during inflight refueling procedures and no difficulties with the somewhat awkward location of the refueling receptacle were noted. KC-135A is shown refueling '1568 during lightweight fighter fly-off competition. General Dynamics*



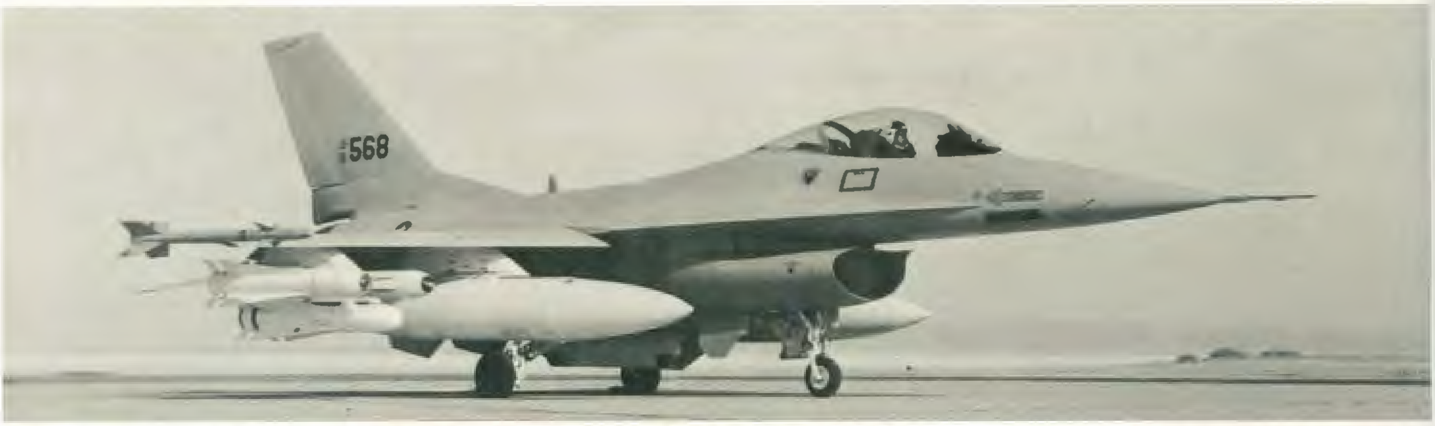
The following table lists the physical and performance characteristics of the two designs at the time of the fly-off:

| | YF-16 | YF-17 |
|---|---|---|
| Wingspan | 30'0" | 35'0" |
| Length | 46'6" | 56'0" |
| Height | 16'3" | 14'6" |
| Wing sweep @ leading edge/ quarter chord | 40-degrees (LE) | 20-degrees (QC) |
| Aspect ratio | 3:1 | 3.5:1 |
| Wing area | 280 sq.' | 320 sq.' |
| Empty weight | 14,023 lbs. | 17,560 lbs. |
| Fuel weight | 6,642 lbs. | 9,400 lbs. |
| Gross weight | 20,665 lbs. | 26,960 lbs. |
| External load | 13,200 lbs. | 18,000 lbs. |
| Max. gross weight | 31,000 lbs. | 38,000 lbs. |
| Combat thrust:weight (afterburner) | 1.28:1 | 1.2:1 |
| Combat wing loading | 75 lbs./sq.' | 78 lbs./sq.' |
| Powerplant | 1 x P&W F100-PW-100<br>23,500 lbs. thrust | 2 x GE YJ101-GE-100<br>14,750 lbs. thrust (ea.) |
| Bypass ratio | 0.7 | 0.20 |
| Combat radius | 600 miles | 576 miles |
| Ferry range | 3,000 miles | 2,900 miles |

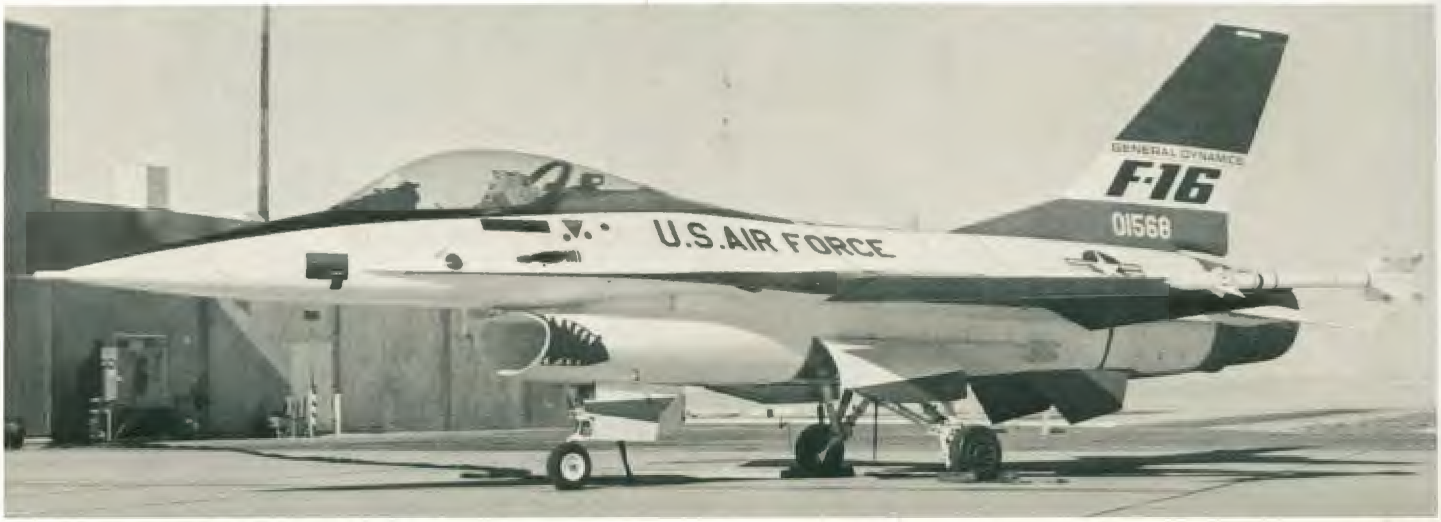




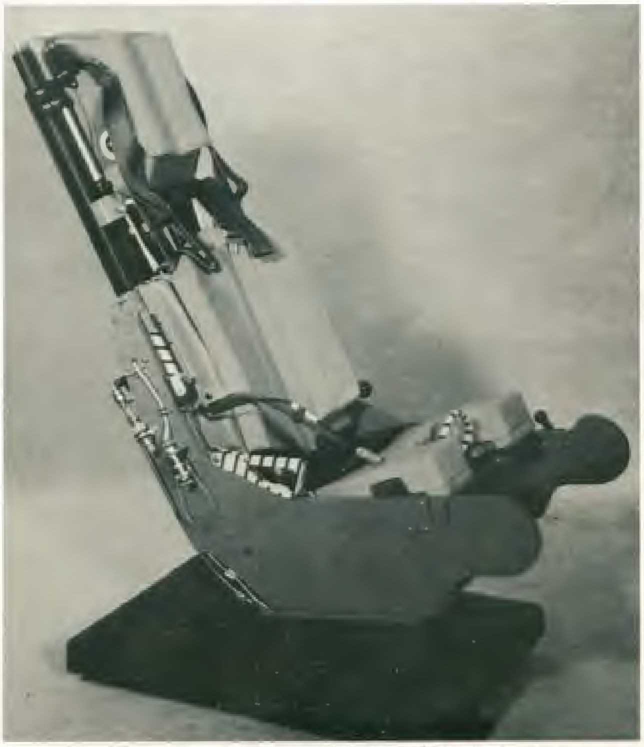
*Three views illustrating the three mounting configurations flight tested on '1568 during Raytheon AIM-7 Sparrow missile trials. Upper photo shows missiles mounted on pylons attached to the main landing gear doors; center photo shows conventional outboard wing pylon mounting; and lower photo shows conventional wing tip rail mounting. General Dynamics*



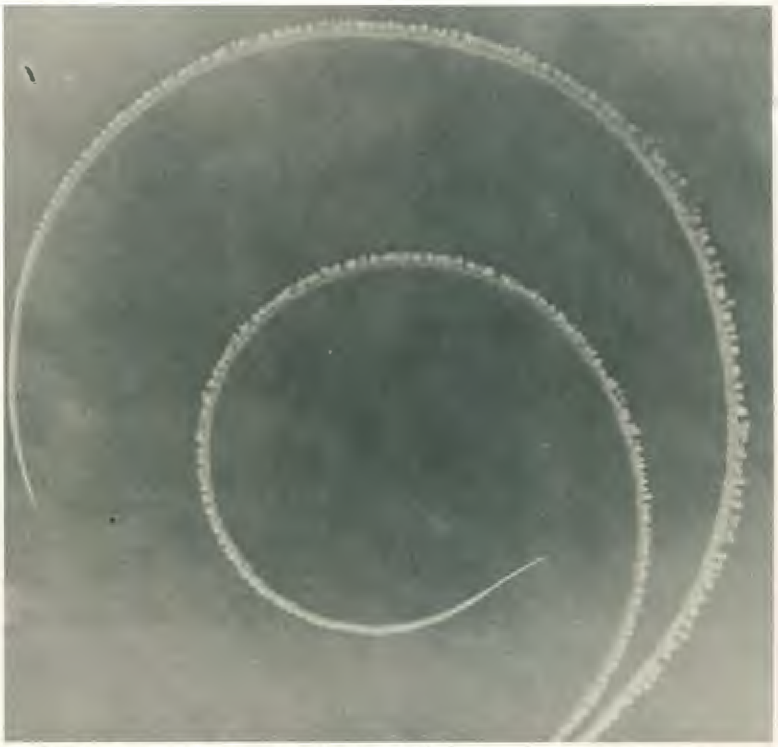
*Sporting a new medium grey paint scheme and an impressive array of wing mounted weapons, '1568 poses for a company photographer while undergoing weapons tests at Edwards AFB. Three AGM-65 Mavericks and an AIM-9 Sidewinder are visible along with massive 370 gallon drop tanks. General Dynamics*



*In yet another paint scheme, this one matching the patriotic markings of '1567 (with the exception of the shark mouth and eyes), '1568 sits at General Dynamics Edwards AFB facility.*



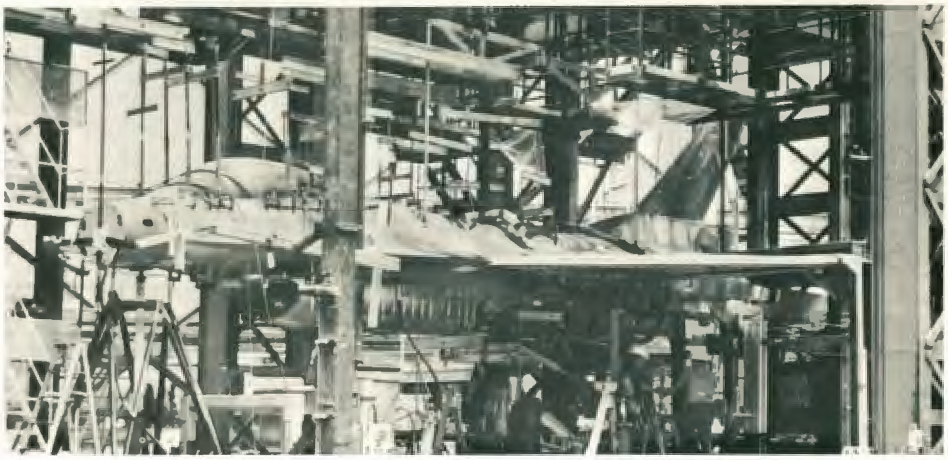
*First two YF-16's flew with Stencel SIIIS ejection seats. Production aircraft have ACES II seats. H.V. Greene via Stencel Aero Engineering Corporation*



*F-16's turn rate is possibly the best of any combat aircraft in the world. Comparison of F-4 and F-16 turn rates is illustrated by this photo. F-4 is the outer contrail. General Dynamics*

# CHAPTER 8

## PRODUCTION BEGINS AND OPERATIONAL SERVICE IS ATTAINED



*Two FSD configured airframes were set aside for static and durability testing. Airframe shown was used for structural test work at General Dynamics. General Dynamics*

While testing of the two YF-16's continued unabated at Edwards AFB, General Dynamics, following its LWF/ACF competition victory, embarked on a massive program to realign its production priorities at its Fort Worth, Texas plant. The last of the original F-111's was now nearing completion and as these aircraft moved down the production lines, old jigs and production equipment were removed or reconfigured, and new ones were installed in their place. Most importantly, provision had to be made for the thousands of new jobs the program was expected to generate (initial General Dynamics estimates were that a total of 55,000 to 60,000 personnel would be employed by the company and its various subcontractors by the time the F-16 production program peaked; currently, in 1982, General Dynamics' Fort Worth Division employs some 16,000).

The operation was an awesome undertaking. General Dynamics' Fort Worth facility is one of the largest aircraft production plants in the world and its main production building stretches just a few feet short of a mile from one end to the other. In order to coordinate production line changes, immense, detailed scale models of the plant and its production runs have been built. Thousands of flow studies and engineering changes are tested on these models long before changes are made to the full-scale hardware.

The General Dynamics victory, somewhat surprisingly, had not at first assured the company that a large order for its new Air Combat Fighter would be forthcoming from the Air Force (and/or Navy). Political pressure remained entrenched within the Air Force bureaucracy calling for termination of the program out of fear that, if approved, it would lead to termination, or at best, curtailment of the sacrosanct F-15 program. In fact, the F-16 program's single saving grace was its unwavering support from the Secretary of Defense. His strong belief in the lightweight fighter philosophy (from the Boyd and Sprey seeds sown several years before) ramrodded the project through to contract signing, and in effect, made the Air Force accept an airplane that it really did not want.

Once the contract was awarded, however, General Dynamics was faced with a three-fold problem. First and foremost, it had to service its Air Force customers and overcome the lingering concerns generated by the ill-fated and mishandled F-111 program—and concomitantly, it had to convince the Air Force that the F-16 was a viable and effective air combat fighter; secondly, it had to mount a massive sales campaign and try to convince NATO members that the F-16 was the best airplane available for the money and the NATO mission (Lockheed and Northrop were also vying for the expected large NATO order); and third, it had to contend with the debate occurring within the confines of the DoD and the Congress as to whether the Navy should be forced to accept a modified F-16 for its forthcoming fighter requirements (detailed in Chapter 15).

While these and innumerable other manipulations were taking place, the construction preliminaries for the first eight FSD (Full Scale Development) aircraft got underway. Initiated in July of 1975, construction of the first FSD F-16A, 75-0745, consumed just over a year and resulted in an official roll-out on October 20, 1976.

This airplane, with company test pilot Neil Anderson at the controls, took to the air for the first time from General Dynamics' Fort Worth plant on December 8th, and was officially turned over to the Air Force at the same time. On December 17th, it was ferried to Edwards AFB (in formation with the last production F-111), spearheading the FSD flight test program that was scheduled to take place there.

The other FSD F-16A's sporadically rolled from the General Dynamics production line during the following year, with the first two-seat FSD F-16B, 75-0751, taking to the air on August 8, 1977. These aircraft, in order of their completion, were assigned the following test program responsibilities (there were two airframes built for static test and durability test work which were never flown, but rather tested to destruction):

FSD #1—flutter, propulsion, performance, and flying qualities. Delivered in December of 1976.

FSD #2—structure and performance. Delivered in February of 1977.

FSD #3—avionics, fire control system, vibration, accoustics, and electro-magnetic compatibility. Delivered in May of 1977.

FSD #4—flying qualities, performance, avionics, and weapon separation. Delivered in August of 1977.

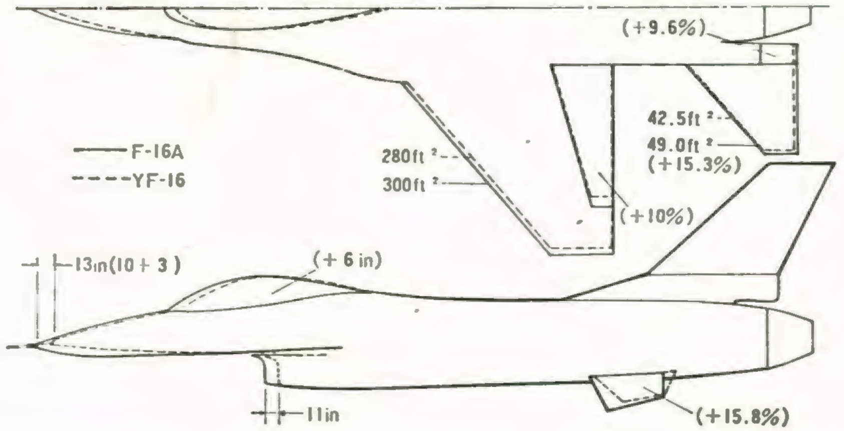
FSD #5—flying qualities, weapon separation, and Seek Eagle. Delivered in November of 1977.

FSD #6—climatic. Delivered in January of 1978.

FSD #7—maintenance and reliability. Delivered in March of 1978.

FSD #8—(first F-16B) maintenance and reliability. Delivered in June of 1978.

As "limited range" had been claimed by the Air Force as rationale for not ordering the F-16, it is interesting to note that during FSD flight test work, two long range missions were flown that proved operationally configured F-16's had the same long legs possessed by the two prototype aircraft. On May 20, 1977, the #2 FSD F-16A, armed with two AIM-9's and its internal M61A-1 rotary cannon, and equipped with two 370 gallon external wing tanks, flew non-stop and non-refueled from Edwards AFB, California to Andrews AFB near Washington, D.C.—a distance of 2,000 nautical miles. When it touched down at Andrews AFB, 18% of its fuel remained. A second long distance flight, utilizing the #3 FSD F-16A armed with two AIM-9's, the internal M61A-1 rotary cannon, and two Mk.84 iron bombs suspended from wing pylons, from Edwards AFB to Carswell AFB near



*Drawing illustrating general dimensional differences between YF-16 prototypes and FSD (Full Scale Development) and production aircraft. Note that vertical fin and much of the aft fuselage remain unchanged. General Dynamics*

*First FSD F-16A (75-0745) fuselage is lifted from jigs and moved to area where it will undergo final stages of primary construction. From there it will move into final assembly and roll-out. Note composite construction of vertical fin and rudder. General Dynamics*

Forth Worth, Texas, covered no less than 1,100 miles non-stop and non-refueled. Note that the latter flight was flown with internal fuel only—there were no wing tanks. Also note that when the airplane landed at Carswell AFB, 21.5% of its takeoff fuel load remained.

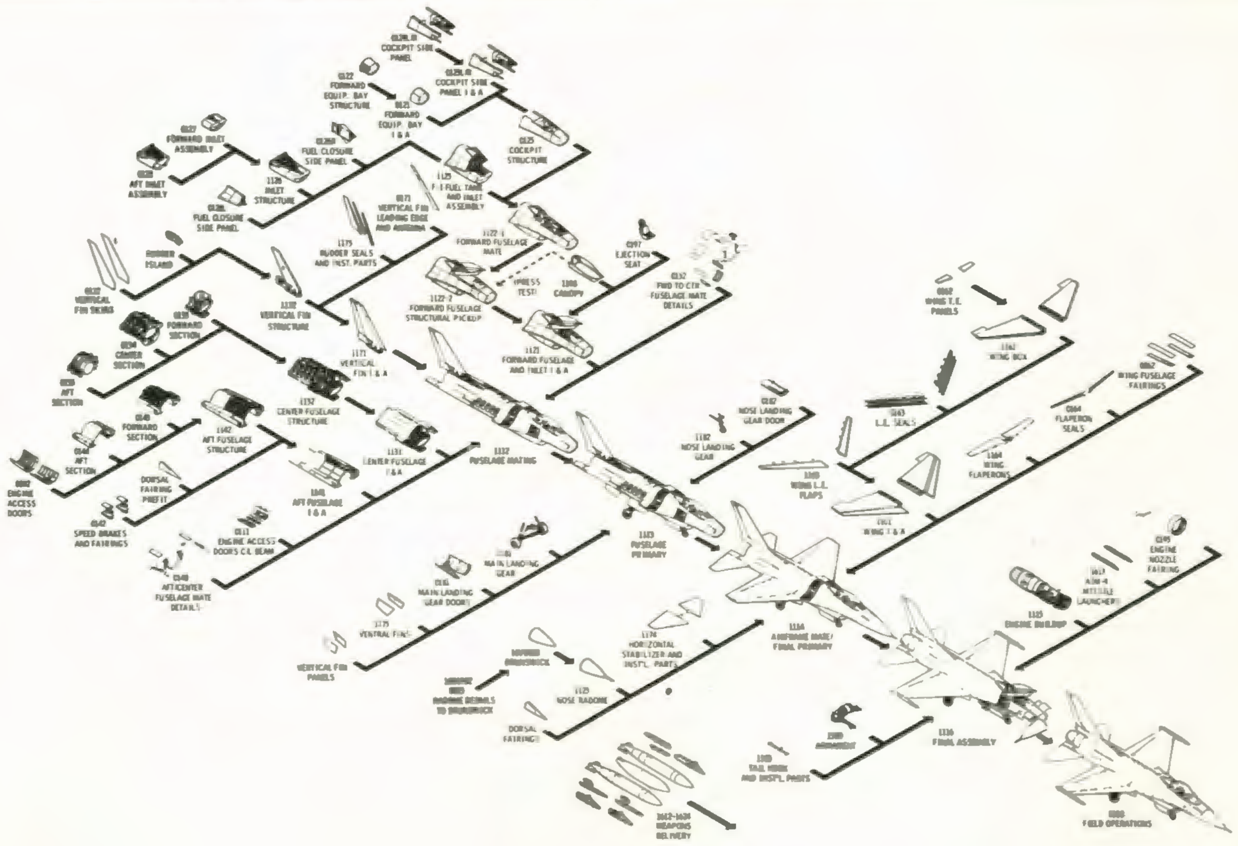
The eight FSD airplanes differed significantly from their two YF-16 predecessors. Besides being slightly larger in almost all dimensional respects, they were also structurally strengthened by 25% (to permit full exploration of the maneuverability envelope; previous fighter specifications had required 7.33 g @ 80% internal fuel—the F-16 was capable of 9 g at full internal fuel at all flight conditions), they had greater wing area (by some 20 sq. ft.; this also improved long term growth potential), and they had 15% more horizontal tail surface area. Not as easily discerned was the fact that they also had self-contained jet-fuel engine starters and increased external store-carrying capability on nine wing and fuselage stores stations.

Flight testing of the FSD aircraft was conducted primarily at Edwards AFB. At the same time, the two prototype YF-16's were committed to promotion and further test work, and in consideration of the former, they were, on several occasions, flown to various bases and various foreign countries.

In the spring of 1978, the Secretary of Defense announced that $1,900,000,000 had been authorized by Congress to start F-16 production. This contract called for 105 aircraft for the Air Force, 192 aircraft for Europe (part of the 348 aircraft ordered by NATO—to be detailed in Chapter 14), and 55 for Iran (out of a total order for 160). Air Force and NATO orders were subsequently increased, with the Air Force settling on 1,388 aircraft (though, as of this writing, the Air Force appears to be likely to receive at least 945 more).

The first full production aircraft (and the first to be completed following the original 8-aircraft FSD run), 78-0001, took to the air in August of 1978 and was officially turned over to the Air Force the same month. Additional production aircraft followed on a monthly basis through November, with a gap occurring in December due to company holidays and production scheduling.

The first Air Force aircraft were delivered to the 388th Tactical Fighter Wing at Hill AFB, Utah (and eventually assigned to the 4th, 34th, and 421st Tactical Fighter Squadrons, and the 16th Tactical Fighter Training Squadron), which conveniently, was also the home of the Ogden Air Logistics Center (which had been designated the prime overhaul and material depot for the F-16 with all depot-level maintenance and spares procurement being its responsibility). The 388th had been picked as the first to receive the type for a number of reasons, not the least of which was its rather ideal location and its accessibility to the Wendover Test Range—which permitted unrestricted weapons and air combat testing. Arrival ceremonies took place at Hill on January 6, 1979, with some 30,000 people in attendance.



*Flow charts such as this give insight into how the various F-16 parts and subassemblies come together in order to form the complete airplane. General Dynamics*

As 388th TFW F-16 experience was accumulated following the type's arrival, a number of noteworthy developments took place including the fact that almost all F-16 training procedures were evolved using 388th aircraft and pilots. In consideration of this, the 16th Tactical Fighter Training Squadron also became the unit responsible for training the first international pilots. The 388th also flew the first operational test missions with the F-16, and by scoring well in the first F-16 Operational Readiness Inspection (ORI), it became the first F-16 wing to be declared combat ready. In the spring of 1981 it also became the first unit to deploy overseas with the F-16 when the 4th TFS spent a month at Flesland, Norway in the Coronet Falcon operational exercise.

The second base to receive the F-16 was MacDill AFB, near Tampa, Florida. Serving as an Operational Training Unit, the 56th TFW, comprised of the 61st and 62nd TFTS's, received its first aircraft on October 22, 1979.

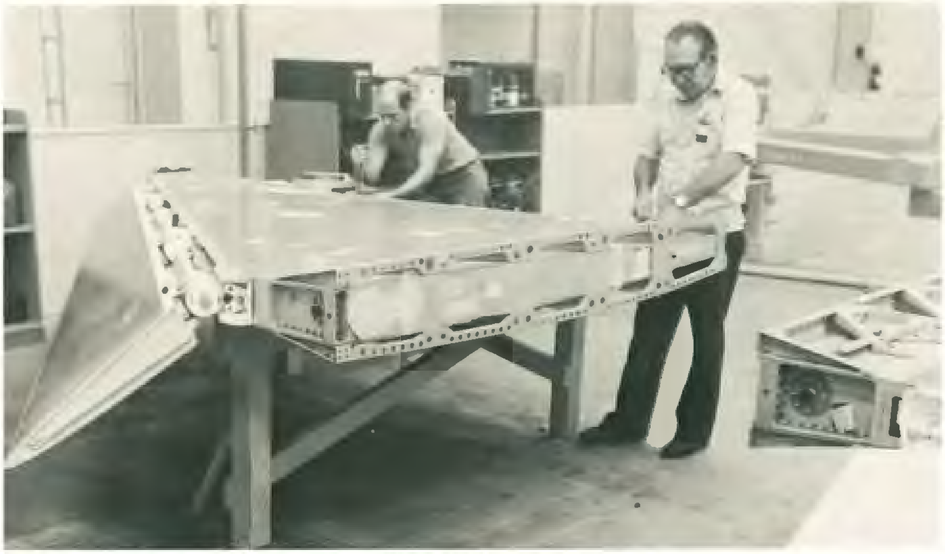
The third base to receive the F-16 was Nellis AFB, Nevada. The first aircraft arrived on November 14, 1980, immediately replacing McDonnell F-4D's of the 474th TFW. A total of 72 F-16's were assigned to Nellis, these equipping the 428th, 429th, and 430th TFS's.

The first overseas based F-16's were those of the 8th TFW which arrived at Kunsan AFB, South Korea on June 26, 1981. Both 8th TFW F-4D squadrons, the 35th and 80th, have now converted to the F-16. The 8th TFW's 497th TFS at Taegu AB is also expected to transition to F-16's. Another overseas assignment will occur with the completion of F-16 deliveries to Hahn AB in Germany. There, the 50th TFW, consisting of the 10th, 313th, and 496th TFS's, will trade-in its F-4 complement for F-16's. The F-16's are expected to be fully operational on March 23, 1982.

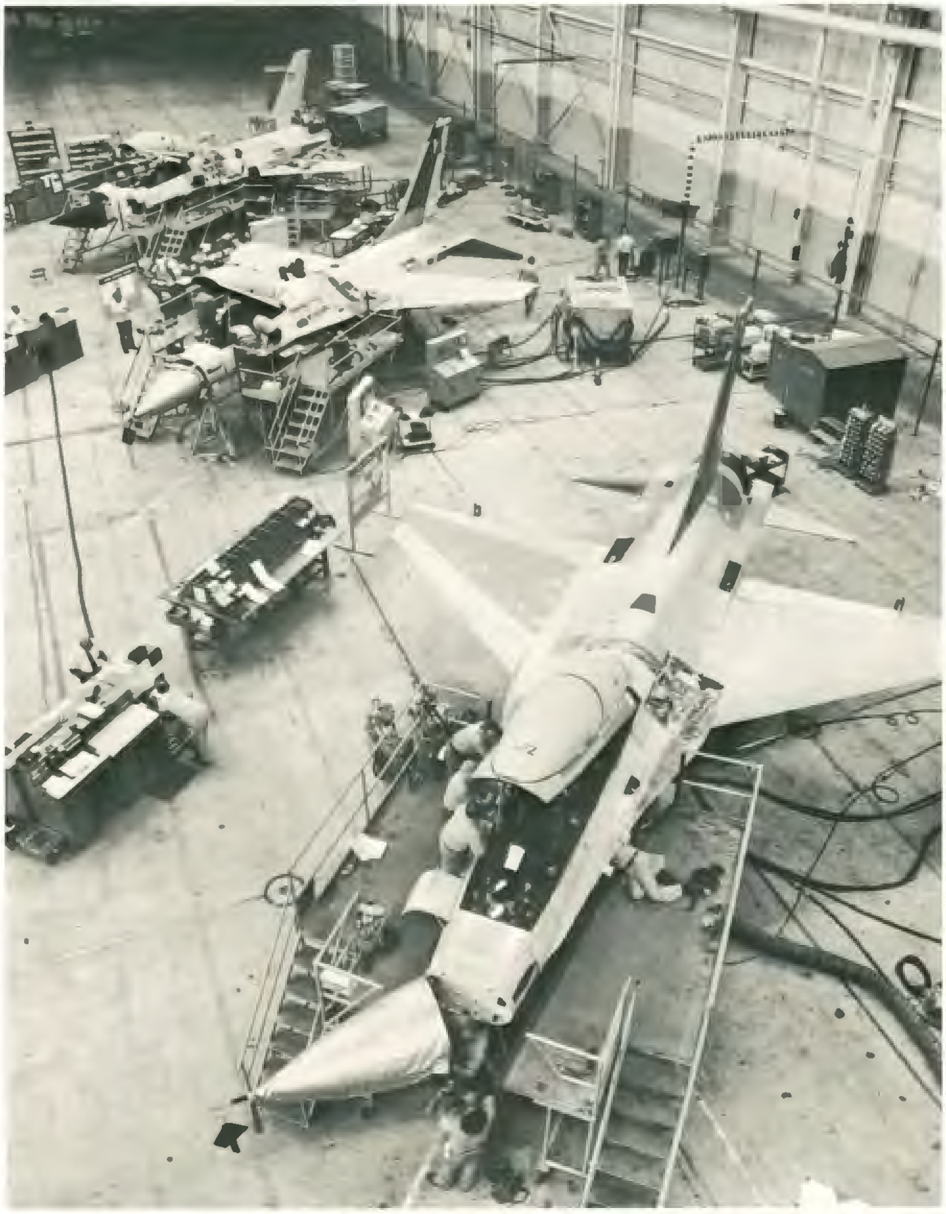
As additional aircraft roll from the General Dynamics production lines at a production rate of ten per month, further wings and squadrons will be equipped with the F-16. One of the better known forthcoming transitions is that of the 363rd TFW at Shaw AFB, South Carolina. This unit, currently a Tactical Reconnaissance Wing, is flying McDonnell RF-4C's. It will become a Tactical Fighter Wing once transition to the F-16 is completed. Three F-16 squadrons are scheduled to replace a similar number of RF-4C squadrons. Interestingly, one squadron of RF-4C's will be retained (the remaining RF-4C's are to be transferred to Bergstrom AFB, Texas).

The Air National Guard and the Air Force Reserve are also expected to begin transitioning to the new airplane as availability permits. The first scheduled Guard unit to receive the type will be the 169th TFGp at McEntire ANGB, near Columbia, South Carolina. Twenty-four aircraft are scheduled for this unit (which is currently equipped with A-7's) and transition is to take place during the first quarter of 1983. The first Air Force Reserve unit to receive the aircraft will be the 508th TFGp at Hill AFB, and these aircraft are expected to arrive in early 1984. The 508th, following transition to the F-16, will become the 499th TFGp. The 466th TFG Reserve unit at Hill will also transition to F-16's, receiving a total of 24 (18 initially and 6 at a later date) to replace the present complement of F-105's.

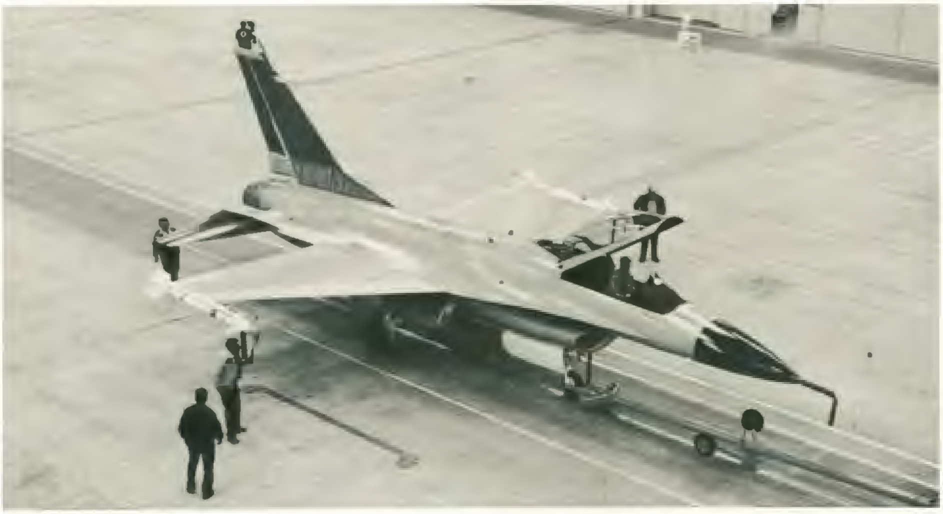
Besides the standard Air Force operational wings and squadrons, F-16's have been assigned to a number of peripheral test and evaluation units. The two most important among these is the somewhat fragmented F-16 program at the Air Force Flight Test Center,



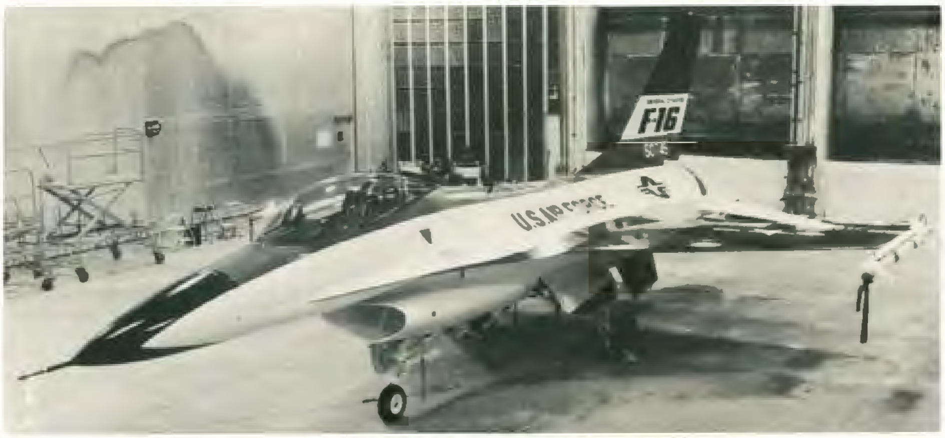
*Wing nearing final assembly following removal from jigs. Note simple leading edge flap and associated hinges. General Dynamics*



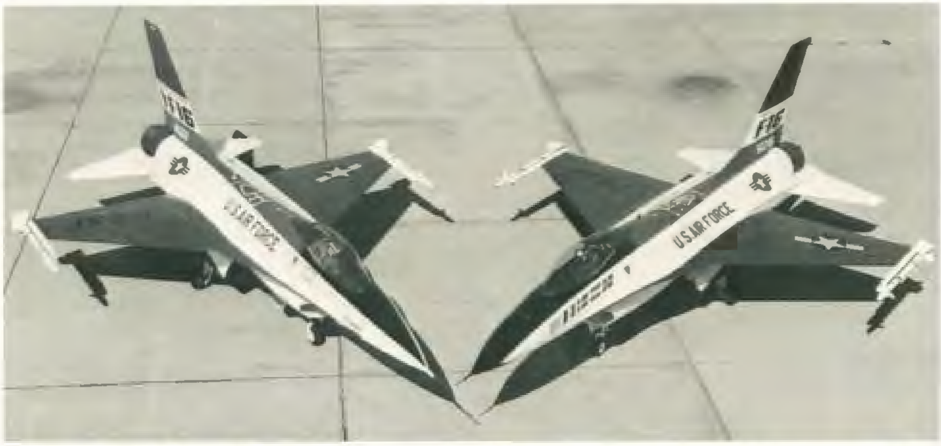
*The last FSD F-16, 75-0752, an F-16B, in final assembly ahead of the first production F-16A 78-0001, and an early production F-16B inside the General Dynamics plant in May of 1978. The FSD F-16B was delivered to the Air Force the following month. General Dynamics*



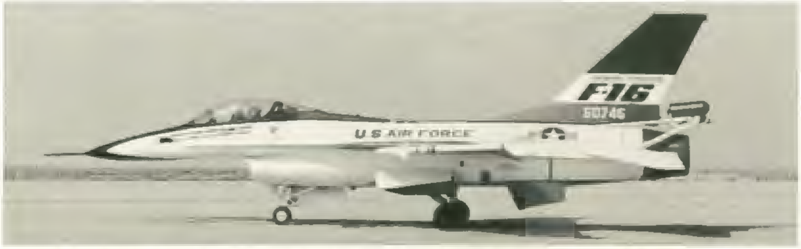
*The first FSD F-16A, 75-0745, is towed through an empty part of the General Dynamics plant production line on its way to the paint shop. General Dynamics*



*With painting almost completed, '0745 needs only the addition of buyer country flags to the forward fuselage to be ready for roll-out. General Dynamics*



*Just prior to its official taxi-out ceremonies, the number one FSD F-16A poses with the number two YF-16. Differences between the two aircraft were subtle, but substantial. General Dynamics*



*Following its arrival at Edwards, '0745 was utilized in an extensive flight test program exploring all facets of the airplane's flight envelope. Here it is seen with anti-spin chute installation during spin portion of flight test program. General Dynamics*

Edwards AFB, California, and the now reconstituted Detachment 16 of the 57th FWW at Hill AFB (which is normally at Nellis AFB).

The AFFTC operation has been a cooperative effort under the primary sponsorship of the Air Force and General Dynamics. The latter, like most major US aerospace contractors, operates a government-furnished facility at Edwards AFB from which to conduct F-16 flight test work. All preliminary testing of prototype aircraft occurred from this facility, and advanced development work continues to this very day. The extensive FSD F-16 program (which validated structural integrity, performance, flying qualities, flutter, propulsion, ECS, secondary power, equipment subsystems, stores separation, fire control and navigation, penetration aids, communication and identification, electromagnetic impulse characteristics, and lightning strike protection) was also conducted at Edwards AFB and several of these aircraft remain at the site for continuing research into new aircraft and weapon systems. New F-16's are periodically cycled through the Edwards AFB/General Dynamics facility for development and test work.

Detachment 16 of the 57th FWW was an unusual operation. Responsible for the Multinational Operational Test and Evaluation (MOT&E) program for the F-16, this unit, on September 22, 1978, came together under the auspices of a five nation (Belgium, Denmark, the Netherlands, Norway, and the US) test program.

This project called for each participating nation to contribute aircraft, manpower, and support materials in order for the F-16 to be evaluated under operational conditions. Part of this evaluation included development of tactics and employment concepts.

The US MOT&E team consisted of Tactical Air Command (TAC), Air Training Command (ATC), Air Force Logistics Command (AFLC), Air Force Systems Command (AFSC), and Air Force Test and Evaluation Center (AFTEC) personnel. Similarly responsible personnel were supplied by the European contingent.

Flight testing under the auspices of the MOT&E, utilizing nine aircraft and eighteen pilots (10 US and 2 from each European country), consisted of a year at Nellis flying ordnance delivery and air combat missions into various California and Nevada desert test ranges. Some 4,130 sorties, accumulating no less than 5,179.2 logged hours, were flown.

Once this was completed, six of the nine F-16's and 120 support personnel were moved to Europe where six weeks were spent at each of four European bases: Leeuwarden in the Netherlands (from June 20th to August 7th); Skrydstrup in Denmark (from August 7th to September 18th); Beauvechain in Belgium (from September 18th to October 30th); and Rygge in Norway (from October 30th to December 15th). No less than 700 hours were logged during this 24 week session which consisted of missions exploring point area defense, air intercept, air superiority, force protection, close air support, interdiction, maritime operations, strike missions, and common operation. During the course of these missions, a diverse collection of air-to-surface ordnance was evaluated under a variety of European weather conditions.

Besides flight testing, the MOT&E explored, under the guidance of the Operational Suitability Test Team, the reliability and maintainability of the aircraft systems and weapons systems, and evaluated the integrated F-16 logistics system. F-16 reliability has been exceptional.

During the first quarter of 1981, the mean flight time between failures in hours was approaching 2.5, and the mature reliability goal for mid-1982 was 3.0. Original reliability predictions proved somewhat conservative as these same reliability figures were 1.8 and 2.3 respectively, when first estimated by General Dynamics at the beginning of the program.

Reliability improvement warranty provisions have been made for critical components, and selective redundancy has been designed into onboard equipment and systems. As with most contemporary state-of-the-art combat aircraft types, the F-16 has automatic fault isolation systems that theoretically reduce maintenance manpower and support equipment requirements. Additionally, onboard mechanical systems have integral failure indicators on filters, valves, and other mission critical components. Test points are built into the electrical and cooling systems. A 95% self-test confidence has been designed into the avionics equipment, and where self-test is not possible, built-in-test equipment (BITE) provisions have been added. The avionics control panels have a test position on the mode selector switches and a digital read-out displays future mode and troubleshooting information.

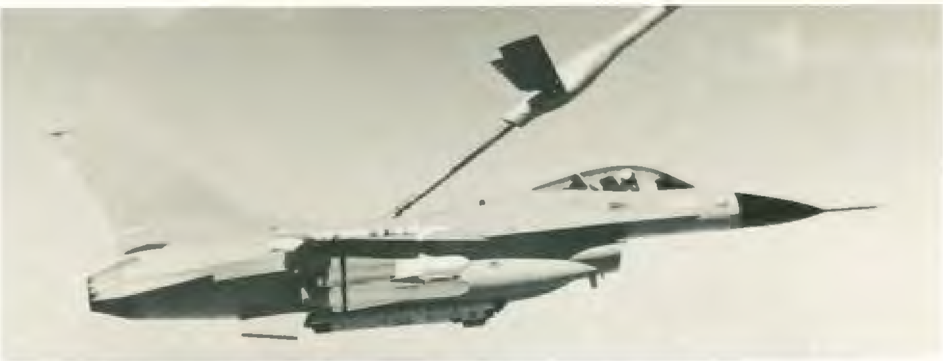
Approximately 60% of the skin of the F-16 consists of removable panels which expose some 80% of the airplane's internal equipment. This permits eye-level maintenance and improves maintenance technique and speed significantly. Some 228 quick-access doors are also provided, these permitting access for engine change, inspection, servicing, and weapons loading. Interchangeable modular equipment reduces on-board maintenance requirements on the airplane, the "remove and replace" concept allowing module replacement on the flight line and depot-level repair for the modules. No flight line calibration or alignment of the modules is required.

Air Force F-16 maintenance programs provide for maintenance at the Wing level, with an Aircraft General Squadron (AGS) assigned to the parent wing and divided into Aircraft Maintenance Units (AMU's). Each AMU is designated by the same number as that of the tactical fighter squadron it supports (428th, 428th, etc.). Two APG (crew chief) flights, one specialist flight, and one weapons flight comprise an AMU.

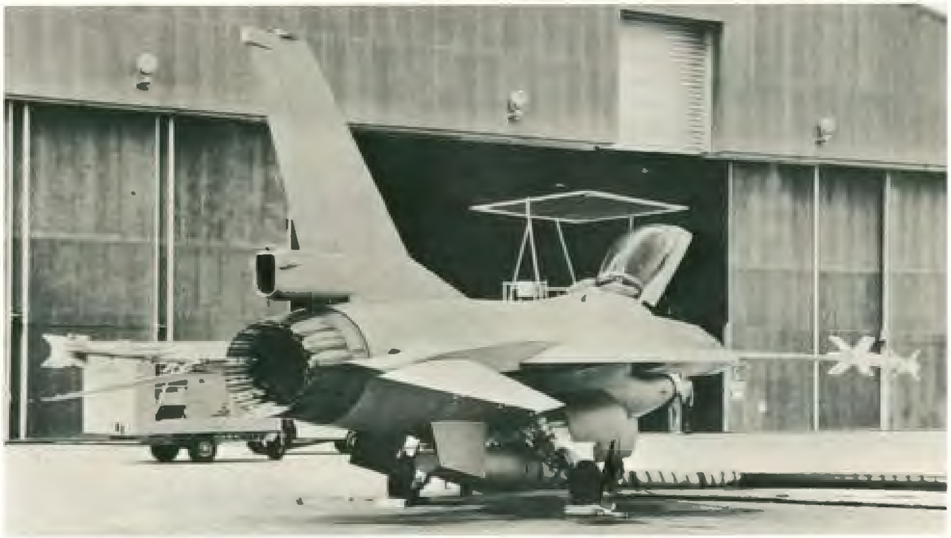
General maintainability of the F-16 while in service, due in great part to its modular construction and use of reliable powerplant and avionics systems, has been exceptional. General Dynamics quality control has also been above average, with 81 zero defect aircraft having been delivered as of April of 1981, and 82 more delivered with less than 5 defects. One of the 81 zero defect aircraft (78-065) was considered "perfect" upon Air Force acceptance.

F-16 mission capable rates have run some 5% to 10% higher than the Tactical Air Command standard (70%), and the full mission capable rate has averaged from 10% to 15% higher than standard (50%). By comparison, the McDonnell Douglas F-15 has averaged 12% *below* and *at* the average for mission capable and full mission capable requirements, respectively. Flight and maintenance crews have attained a high level of confidence in the airplane and even this has improved with the spreading availability of dedicated F-16 support equipment throughout the world.

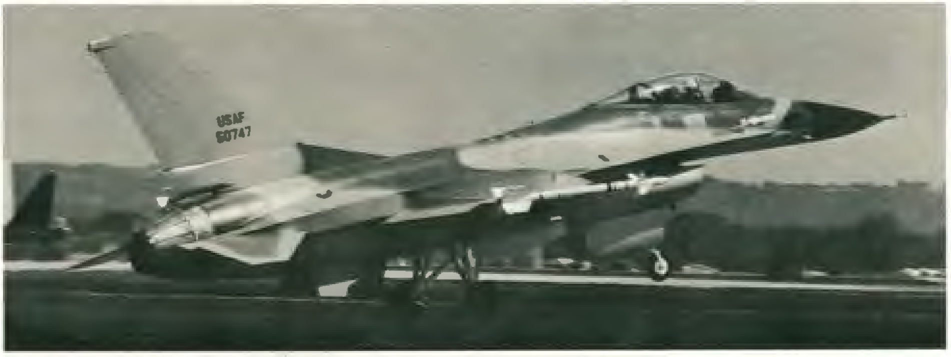
The achilles heel for the F-16, like the F-111D and the F-15, is the computerized avionics intermediate shop (AIS). The AIS is currently experiencing reasonable reliability,



*The number two FSD F-16A takes on fuel from a KC-135A during pre-production flight test program at Edwards AFB. Airplane is equipped with AGM-65 Maverick missiles, two 370 gallon drop tanks, and a center-line-mounted ALQ-131 ECM pod. General Dynamics*



*The number one FSD F-16A, '0745, was modified late in its flight test program to incorporate the Norwegian drag chute and housing at the base of its vertical fin. Airplane is seen at Edwards AFB during the course of drag chute tests. James Goodall*



*The number three FSD F-16A, '0747, was the first of the pre-production F-16A's to be equipped with a full avionics and fire control system complement. It also flew with a non-standard dark grey on grey camouflage pattern not seen on any other F-16. It is shown taking off on its first flight which occurred on May 3, 1977. General Dynamics*

*With its non-standard paint scheme drying, '0747 sits in General Dynamics paint shop shortly after completion and several days away from its first flight. General Dynamics*

*The fifth FSD F-16A, '0749, served as the weapons separation test airplane. Here it is seen over Edwards AFB, moving in for an inflight refueling hook-up during the course of iron bomb drop tests. Four Mk. 82 500 pound bombs are seen hung from inboard wing pylon racks.* General Dynamics

*The first FSD F-16B was 75-0751 which was delivered to the Air Force in August of 1977. In the view above, airplane has become first F-16B to be equipped with new increased-area horizontal tail surfaces. In view below, airplane is shown shortly after roll-out.* General Dynamics

but there are serious shortcomings in the AIS technical orders—engineering data and drawings. Although the F-16 AIS program has learned from the mistakes and deficiencies of the F-15 AIS program (moving to a greater degree of parts commonality and reduced complexity of interface test adapters (ITA's)), the F-16 AIS, like the F-15 AIS, is characterized by a 25% cannot duplicate rate (CND). The CND rate represents a mismatch between aircraft built-in-test equipment (BITE) and the AIS diagnostic test program, and magnifies the requirements for expensive serviceable spares to support a given level of aircrew training.

For the training of F-16 pilots, two Air Force training courses have been developed: Transition Training Course F1600TX for experienced pilots; and Operational Training Course F1600B for those with more basic proficiency in flying skills (usually pilots fresh out of advanced training). Both courses are being utilized at Hill and MacDill AFB's by the 388th and 56th TFW's, respectively.

In the F1600TX course, pilots receive 19 days of ground school and 33 flying days. Prerequisites include 300 hours as a first pilot or instructor pilot in tactical fighter/attack aircraft within the preceding 42 months; or 500 hours of such experience within the preceding 60 months; or 1,000 hours within the preceding 96 months.

Classroom studies consist of 335 hours of conversion, air-to-air instruction, and air-to-surface weapons training. Some 27 hours of this is spent utilizing aircrew training devices.

Actual flight training includes seven conversion flights, an introduction to or review of basic fighter maneuvers, dissimilar aircraft maneuvers, basic attack maneuvers, surface attack and night surface attack procedures, and surface attack tactics. Twenty-two sorties are usually flown as part of this latter program,

The 300th General Dynamics-built F-16, 79-0353, is seen at the Fort Worth plant shortly after completion. This airplane was production number 316 and was delivered to the Air Force in December of 1980. It was placed in service at MacDill AFB, Florida. General Dynamics

An early production F-16A is towed from final assembly and into the paint shop. General Dynamics

Thirty-five years separate the Confederate Air Force's Republic P-47N and General Dynamics F-16A's 79-0332 and 79-0333. General Dynamics

Another study in contrast. North American P-51D owned by Jay Cullum of Dallas, Texas, flies formation with F-16A 78-0067. General Dynamics

these including at least three inflight refueling exercises. Weapons/range requirements include proficiency with the 20mm M61A-1 rotary cannon (850 rounds are provided), the BDU-33 low drag weapon simulator, the Mk.106 practice bomb, the inert Mk.82 and Mk.84 iron bombs, and flares.

The F1600B course is somewhat longer than that for F1600TX. It lasts 109 days and includes 18 days of ground training and 91 days of flight training. The basic prerequisite is that the student pilot has satisfactorily completed the TAC fighter Lead-In Course conducted in Northrop T-38's (consisting of 334.8 hours of classroom time and 32.5 hours of aircraft training devices time).

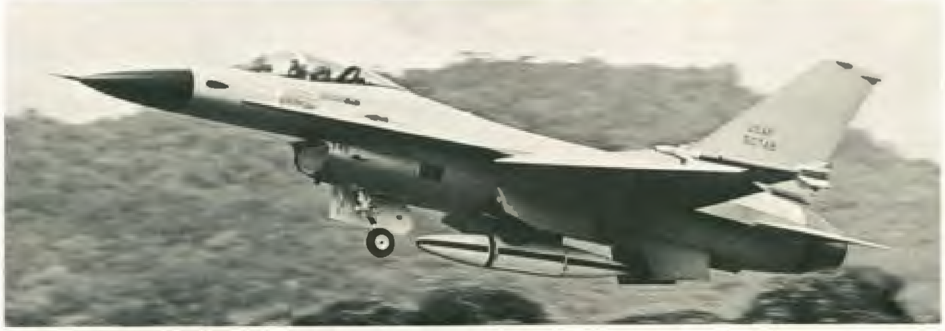
The scheduled 82.6 hours of flight time is usually accomplished in 60 sorties. Flying training includes transition, instrument flying, basic aircraft handling, formation flying, intercept operations, and then a similar flying syllabus to F1600TX. Two inflight refuelings are usually required as well as weapons/range requirements calling for the use of the M61A-1 (3,350 rounds are provided), the BDU-33 low drag weapon simulator, the Mk.82 and Mk.84 iron bombs, and the Mk.106 practice bomb.

Completion of Course F1600B produces a pilot who is able to intercept, engage and defend against single target aircraft, is qualified in attacks on the Dart tow target, and has limited proficiency in night surface attacks using conventional weapons delivery. Remaining qualifications training is received from the assigned operational unit.

During service testing and competition, the F-16 has indeed proven itself to be an exceptionally capable and undemanding airplane. Seven 388th TFW aircraft and their crews performed most commendably during the RAF inter-service tactical bombing meet held at RAF Lossiemouth in mid-1981. Flying in com-

The first F-16 to fly with the new increased-area horizontal tail surfaces was FSD F-16A number two, 75-0746. General Dynamics

F-16B, 79-0414, production number 215, was delivered to the Air Force in August of 1980. General Dynamics petition with BAC *Jaguars* and Hawker Siddeley *Buccaneers* of the RAF, and Air Force F-111E's, the F-16's scored a winning 7,831 points out of a possible total of 8,000. In compiling this impressive figure, the F-16's unerringly delivered their bombs on target and they achieved 88 air-to-air victories over RAF BAC *Lightnings* and McDonnell F-4's—against 0 losses. Just as impressively, F-16 maintenance teams averaged a 10.5 minute turn-around time while refueling the aircraft and loading six 500 pound Mk.82 iron bombs and 515 rounds of 20mm ammunition per aircraft. Though unnamed critics of the competition were quick to point out several failings in the scoring system—and the fact that this was primarily a paper and computer exercise, it remains



*F-16A 75-0749 was the sixth FSD F-16A. It is shown equipped with test aerodynamic shape, possibly related to proposed installation of 40" focal-length HIAC reconnaissance camera.* USAF

*Clean F-16A of the 34th taxies out for takeoff during transient stop at Bergstrom AFB, Texas. Aerofax*

*Sporting special vertical fin markings indicating commander's airplane, 34th TFS F-16B, 78-0115, sits on ramp at Offutt AFB, Nebraska during transient stop. George Cockle*

The following is a listing of F-15 and F-16 flight limitations as they compare to each other (based on no wing tanks or air-to-surface stores):

| F-15 | Head-Down Ref. Req'd. F-15/F-16 | F-16 |
|---|---|---|
| Flight above 7.33g | Yes/No | Flight above 9g |
| Flight above 20-degrees angle-of-attack with 200 pound wing fuel asymmetry | Yes/— | No limits |
| Zero g flight, except transient | No/No | Negative g flight in excess of 30 secs. in Mil power, 10 secs. in Max power |
| Flight above 20-degrees angle-of-attack with gear down | Yes/— | No limits |
| Full lateral stick rolls in excess of 180-degrees less than +1.0 g or greater than +3.0 g | Yes/Yes | Full lateral stick rolls at less than −1.0 g or greater than +5.86 g |
| Rolls in excess of 180-degrees at other than +1.0 g above 550 KCAS or Mach 1.4 | Yes/— | No limits |
| Full lateral stick rolls greater than 360-degrees | No/No | Max command rolls greater than 360-degrees |
| Abrupt rolls above 475 KCAS above 12,000' | Yes/— | No limits |
| Rolls in excess of 360-degrees above 550 KCAS or Mach 1.4 | Yes/— | No limits |
| Rolls in excess of 90-degrees with gear down | No/No | Rolls in excess of 180-degrees with gear down |
| Spins | No/No | Spins (intentional departures and spins are now allowed on "big tail" aircraft under certain conditions as specified in Operational Supplement 170) |
| Close formation flight above 475 KCAS below 12,000' | Yes/— | No limits |

Units currently operating the F-16 and their respective tail codes and vertical fin stripe colors are:

| TAIL CODE | WING | SQUADRON | BASE | FIN STRIPE COLOR |
|---|---|---|---|---|
| HL | 388th TFW | 4th TFS | Hill AFB | yellow 4 and black lightning bolt on a yellow band |
| HL | 388th TFW | 16th TFTS | Hill AFB | blue and white check band |
| HL | 388th TFW | 34th TFS | Hill AFB | 4 black stars on a red band |
| HL | 388th TFW | 421st TFS | Hill AFB | red hourglass on a black band |
| MC | 56th TFW | 61st TFTS | MacDill AFB | yellow band |
| MC | 56th TFW | 62nd TFTS | MacDill AFB | blue band |
| MC | 56th TFW | 63rd TFTS | MacDill AFB | red band |
| NA | 474th TFW | 428th TFS | Nellis AFB | white skull/cross-bones on blue band |
| NA | 474th TFW | 429th TFS | Nellis AFB | yellow band |
| WA | 474th TFW | 430th TFS | Nellis AFB | black and yellow check band |
| WP | 8th TFW | 35th TFS | Kunsan AB | blue band |
| WP | 8th TFW | 80th TFS | Kunsan AB | yellow band |
| WP | 8th TFW | 497th TFS | Taegu AB | red band (scheduled to re-equip with F-16's during 1982) |
| HA | 50th TFW | 10th TFS | Hahn AB | blue band |
| HA | 50th TFW | 313th TFS | Hahn AB | white band |
| HA | 50th TFW | 496th TFS | Hahn AB | red band |
| SW | 363rd TFW | 17th TFS | Shaw AFB | ·Scheduled to re-equip with F-16's beginning in March 1982. |
| SW | 363rd TFW | 19th TFS | Shaw AFB | |
| SW | 363rd TFW | 33rd TFS | Shaw AFB | |
| SC | 169th TFG | 157th TFS | Shaw AFB | |
| — | 508th TFG (to 499th) | — | Hill AFB | |
| — | 466th TFG | — | Hill AFB | |

apparent that the F-16 is an effective and viable weapon with capabilities superior to any other allied tactical combat aircraft.

It is important to note that the F-16's many achievements, from conception to successful operational deployment, have come about against great odds and even though the airplane remains an unwanted entity within Air Force environs. The primary reason for this, as has already been mentioned several times throughout this book, is the fact that the Air Force hierarchy remains convinced that the airplane can not do what its proponents, designers, and builders claim. They also remain convinced that the F-15, an airplane of significantly larger proportions and commensurately greater cost, offers many advantages over the F-16 and that arguments to the contrary can not possibly hold water.

Perhaps the saddest aspect of this technocratic tunnel vision is the fact that the Air Force, in order to maintain the F-16 in the poorest light possible, insists on using it for the air-to-ground role (The 388th TFW and the 474th TFW, for instance, now have primary mission assignments that are totally air-to-surface attack. Their *secondary* responsibility is air-to-air combat. Approximately 80% of aircrew flying training time in these two wings is dedicated to air-to-surface attack and 20% to air-to-air. The air-to-air training is designed for defensive {self-protection} purposes only —a role for which it was not originally intended. Somewhat embarrassingly for the Air Force, the F-16 has proven itself almost as capable in the air-to-ground mission as it is in the air-to-air. Even though it does not have the dedicated delivery systems technically required, it has none-the-less scored high in competitions and it continues to meet or exceed requirements.

The Air Force's main concern, of course, is that the F-16, if allowed to show its awesome capabilities, will quickly undermine what little support remains for the F-15. It is well known, for instance, that the F-16 has significantly greater range than the F-15, but it is not so well known that the F-16 is the superior air-to-air combat platform. The latter, in fact, is one of the Air Force's better kept secrets—because that is the exact mission the F-15 is dedicated to perform.

As of the date of this book, with over 100,000 missions and nearly 155,000 hours logged, over 350 F-16's have been delivered to the Air Force and over 250 have been delivered to NATO air forces. These aircraft have averaged some 15.7 sorties per aircraft per month with a mission capable rate of 75.4%.

Total F-16 sales presently stand at over 2,500 with at least 1,388 going to the Air Force and another 650 going to foreign customers. Some 22 squadrons are expected to be operational by late 1983.

The following is a complete listing of the first 700 F-16's either completed as of the date of this book, or scheduled for delivery during the first half of 1982 (note: for future reference, this listing also contains all foreign production aircraft; also note that because of mid-production line changes in scheduling and delivery, some of the airframe numbers may not accurately relate to the recipient air force; also note that the first eight FSD aircraft are now officially designated YF-16A and YF-16B).

| Production Number | Model | Country | Type Version | Tail Number | Delivery Date |
|---|---|---|---|---|---|
| 1 | F-16A | USAF | 61-1 | 75-0745 | DEC 76 |
| 2 | F-16A | USAF | 61-2 | 75-0746 | FEB 77 |
| 3 | F-16A | USAF | 61-3 | 75-0747 | MAY 77 |
| 4 | F-16B | USAF | 62-1 | 75-0751 | AUG 77 |
| 5 | F-16A | USAF | 61-4 | 75-0748 | NOV 77 |
| 6 | F-16A | USAF | 61-5 | 75-0749 | FEB 78 |
| 7 | F-16A | USAF | 61-6 | 75-0750 | APR 78 |
| 8 | F-16B | USAF | 62-2 | 75-0752 | JUN 78 |
| 9 | F-16A | USAF | 61-7 | 78-0001 | AUG 78 |
| 10 | F-16A | USAF | 61-8 | 78-0002 | SEP 78 |
| 11 | F-16B | USAF | 62-3 | 78-0077 | OCT 78 |
| 12 | F-16B | USAF | 62-4 | 78-0078 | NOV 78 |
| 13 | F-16B | USAF | 62-5 | 78-0079 | JAN 79 |
| 14 | F-16B | BAF | 6J-1 | 78-0162 | JAN 79 |
| 15 | F-16A | USAF | 61-9 | 78-0003 | FEB 79 |
| 16 | F-16A | BAF | 6H-1 | 78-0116 | FEB 79 |
| 17 | F-16B | USAF | 62-6 | 78-0080 | FEB 79 |
| 18 | F-16A | USAF | 61-10 | 78-0004 | MAR 79 |
| 19 | F-16A | BAF | 6H-2 | 78-0117 | MAR 79 |
| 20 | F-16B | USAF | 62-7 | 78-0081 | MAR 79 |
| 21 | F-16B | USAF | 62-8 | 78-0082 | APR 79 |
| 22 | F-16B | BAF | 6J-2 | 78-0163 | APR 79 |
| 23 | F-16A | USAF | 61-11 | 78-0005 | APR 79 |
| 24 | F-16B | USAF | 62-9 | 78-0083 | APR 79 |
| 25 | F-16A | USAF | 61-12 | 78-0006 | MAY 79 |
| 26 | F-16A | BAF | 6H-3 | 78-0118 | MAY 79 |
| 27 | F-16B | USAF | 62-10 | 78-0084 | MAY 79 |
| 28 | F-16A | USAF | 61-13 | 78-0007 | MAY 79 |
| 29 | F-16B | USAF | 62-11 | 78-0085 | MAY 79 |
| 30 | F-16A | USAF | 61-14 | 78-0008 | JUN 79 |
| 31 | F-16A | BAF | 6H-4 | 78-0119 | JUN 79 |
| 32 | F-16B | RNLAF | 6E-1 | 78-0259 | JUN 79 |
| 33 | F-16B | USAF | 62-12 | 78-0086 | JUN 79 |
| 34 | F-16A | USAF | 61-15 | 78-0009 | JUN 79 |
| 35 | F-16B | USAF | 62-13 | 78-0087 | JUN 79 |
| 36 | F-16A | USAF | 61-16 | 78-0010 | JUN 79 |
| 37 | F-16B | USAF | 62-14 | 78-0088 | JUL 79 |
| 38 | F-16B | BAF | 6J-3 | 78-0164 | JUL 79 |
| 39 | F-16A | RNLAF | 6D-1 | 78-0212 | JUL 79 |
| 40 | F-16A | USAF | 61-17 | 78-0011 | JUL 79 |
| 41 | F-16B | USAF | 62-15 | 78-0089 | JUL 79 |
| 42 | F-16A | BAF | 6H-5 | 78-0120 | JUL 79 |
| 43 | F-16A | USAF | 61-18 | 78-0012 | JUL 79 |
| 44 | F-16B | USAF | 62-16 | 78-0090 | JUL 79 |
| 45 | F-16A | USAF | 61-19 | 78-0013 | AUG 79 |
| 46 | F-16A | BAF | 6H-6 | 78-0121 | AUG 79 |
| 47 | F-16A | RNLAF | 6D-2 | 78-0213 | AUG 79 |
| 48 | F-16B | USAF | 62-17 | 78-0091 | AUG 79 |
| 49 | F-16A | USAF | 61-20 | 78-0014 | AUG 79 |
| 50 | F-16B | USAF | 62-18 | 78-0092 | AUG 79 |
| 51 | F-16A | BAF | 6H-7 | 78-0122 | AUG 79 |
| 52 | F-16A | RNLAF | 6D-3 | 78-0214 | AUG 79 |
| 53 | F-16A | USAF | 61-21 | 78-0015 | AUG 79 |
| 54 | F-16B | USAF | 62-19 | 78-0093 | AUG 79 |
| 55 | F-16A | USAF | 61-22 | 78-0016 | SEP 79 |
| 56 | F-16A | BAF | 6H-8 | 78-0123 | SEP 79 |
| 57 | F-16B | RNLAF | 6E-2 | 78-0260 | SEP 79 |
| 58 | F-16B | USAF | 62-20 | 78-0094 | SEP 79 |
| 59 | F-16A | USAF | 61-23 | 78-0017 | SEP 79 |
| 60 | F-16B | USAF | 62-21 | 78-0095 | SEP 79 |
| 61 | F-16A | BAF | 6H-9 | 78-0124 | SEP 79 |
| 62 | F-16A | RNLAF | 6D-4 | 78-0215 | SEP 79 |
| 63 | F-16A | USAF | 61-24 | 78-0018 | SEP 79 |
| 64 | F-16B | USAF | 62-22 | 78-0096 | SEP 79 |
| 65 | F-16A | USAF | 61-25 | 78-0019 | OCT 79 |
| 66 | F-16B | BAF | 6J-4 | 78-0165 | OCT 79 |
| 67 | F-16B | RNLAF | 6E-3 | 78-0261 | OCT 79 |
| 68 | F-16B | USAF | 62-23 | 78-0097 | OCT 79 |
| 69 | F-16A | USAF | 61-26 | 78-0020 | OCT 79 |
| 70 | F-16B | USAF | 62-24 | 78-0098 | OCT 79 |
| 71 | F-16A | BAF | 6H-10 | 78-0125 | OCT 79 |
| 72 | F-16A | RNLAF | 6D-5 | 78-0216 | OCT 79 |
| 73 | F-16A | USAF | 61-27 | 78-0021 | OCT 79 |
| 74 | F-16B | USAF | 62-25 | 78-0099 | OCT 79 |
| 75 | F-16A | USAF | 61-28 | 78-0022 | OCT 79 |
| 76 | F-16A | USAF | 61-29 | 78-0023 | NOV 79 |
| 77 | F-16A | BAF | 6H-11 | 78-0126 | NOV 79 |
| 78 | F-16B | RNLAF | 6E-4 | 78-0262 | NOV 79 |
| 79 | F-16B | USAF | 62-26 | 78-0100 | NOV 79 |
| 80 | F-16A | USAF | 61-30 | 78-0024 | NOV 79 |
| 81 | F-16B | USAF | 62-27 | 78-0101 | NOV 79 |
| 82 | F-16A | BAF | 6H-12 | 78-0127 | NOV 79 |
| 83 | F-16A | RNLAF | 6D-6 | 78-0217 | NOV 79 |
| 84 | F-16A | USAF | 61-31 | 78-0025 | NOV 79 |
| 85 | F-16B | USAF | 62-28 | 78-0102 | NOV 79 |
| 86 | F-16A | USAF | 61-32 | 78-0026 | NOV 79 |
| 87 | F-16A | USAF | 61-33 | 78-0027 | DEC 79 |
| 88 | F-16A | BAF | 6H-13 | 78-0128 | DEC 79 |
| 89 | F-16B | RNLAF | 6E-5 | 78-0263 | DEC 79 |
| 90 | F-16B | USAF | 62-29 | 78-0103 | DEC 79 |
| 91 | F-16A | USAF | 61-34 | 78-0038 | DEC 79 |
| 92 | F-16B | USAF | 62-30 | 78-0104 | DEC 79 |
| 93 | F-16A | USAF | 61-35 | 78-0039 | DEC 79 |
| 94 | F-16B | BAF | 6J-5 | 78-0166 | DEC 79 |
| 95 | F-16A | RNLAF | 6D-7 | 78-0218 | DEC 79 |
| 96 | F-16A | USAF | 61-36 | 78-0040 | DEC 79 |
| 97 | F-16B | USAF | 62-31 | 78-0105 | DEC 79 |
| 98 | F-16A | USAF | 61-37 | 78-0041 | DEC 79 |
| 99 | F-16A | USAF | 61-38 | 78-0042 | JAN 80 |
| 100 | F-16B | RDAF | 6G-1 | 78-0204 | JAN 80 |
| 101 | F-16B | RNAF | 6L-1 | 78-0301 | JAN 80 |
| 102 | F-16B | USAF | 62-32 | 78-0106 | JAN 80 |
| 103 | F-16B | IAF | 6W-1 | 78-0355 | JAN 80 |
| 104 | F-16A | USAF | 61-39 | 78-0043 | JAN 80 |
| 105 | F-16A | USAF | 61-40 | 78-0044 | JAN 80 |
| 106 | F-16A | BAF | 6H-14 | 78-0129 | JAN 80 |
| 107 | F-16A | RNLAF | 6D-8 | 78-0219 | JAN 80 |
| 108 | F-16A | USAF | 61-41 | 78-0045 | JAN 80 |
| 109 | F-16B | USAF | 62-33 | 78-0107 | JAN 80 |
| 110 | F-16A | USAF | 61-42 | 78-0046 | JAN 80 |
| 111 | F-16A | USAF | 61-43 | 78-0047 | JAN 80 |
| 112 | F-16A | USAF | 61-44 | 78-0048 | FEB 80 |
| 113 | F-16A | RDAF | 6F-1 | 78-0174 | FEB 80 |
| 114 | F-16A | RNLAF | 6D-9 | 78-0220 | FEB 80 |
| 115 | F-16B | USAF | 62-34 | 78-0108 | FEB 80 |
| 116 | F-16B | IAF | 6W-2 | 78-0356 | FEB 80 |
| 117 | F-16A | USAF | 61-45 | 78-0049 | FEB 80 |
| 118 | F-16A | USAF | 61-46 | 78-0050 | FEB 80 |
| 119 | F-16B | BAF | 6J-6 | 78-0179 | FEB 80 |
| 120 | F-16A | RNAF | 6K-1 | 78-0272 | FEB 80 |
| 121 | F-16A | USAF | 61-47 | 78-0051 | FEB 80 |
| 122 | F-16B | USAF | 62-35 | 78-0109 | FEB 80 |
| 123 | F-16A | USAF | 61-48 | 78-0052 | FEB 80 |
| 124 | F-16A | USAF | 61-49 | 78-0053 | FEB 80 |
| 125 | F-16A | USAF | 61-50 | 78-0054 | MAR 80 |
| 126 | F-16A | RDAF | 6F-2 | 78-0175 | MAR 80 |
| 127 | F-16A | RNLAF | 6D-10 | 78-0221 | MAR 80 |
| 128 | F-16B | USAF | 62-36 | 78-0110 | MAR 80 |
| 129 | F-16B | IAF | 6W-3 | 78-0357 | MAR 80 |
| 130 | F-16A | USAF | 61-51 | 78-0055 | MAR 80 |
| 131 | F-16A | USAF | 61-52 | 78-0056 | MAR 80 |
| 132 | F-16A | USAF | 61-53 | 78-0057 | MAR 80 |
| 133 | F-16A | BAF | 6H-15 | 78-0130 | MAR 80 |
| 134 | F-16A | RNAF | 6K-2 | 78-0273 | MAR 80 |
| 135 | F-16B | USAF | 62-37 | 78-0111 | MAR 80 |
| 136 | F-16A | USAF | 61-54 | 78-0058 | MAR 80 |
| 137 | F-16A | USAF | 61-55 | 78-0059 | MAR 80 |
| 138 | F-16A | USAF | 61-56 | 78-0060 | MAR 80 |
| 139 | F-16A | USAF | 61-57 | 78-0061 | APR 80 |
| 140 | F-16B | RDAF | 6G-2 | 78-0205 | APR 80 |
| 141 | F-16A | RNLAF | 6D-11 | 78-0222 | APR 80 |
| 142 | F-16B | USAF | 62-38 | 78-0112 | APR 80 |
| 143 | F-16A | IAF | 6V-1 | 78-0308 | APR 80 |
| 144 | F-16B | IAF | 6W-4 | 78-0358 | APR 80 |
| 145 | F-16A | USAF | 61-58 | 78-0062 | APR 80 |
| 146 | F-16A | USAF | 61-59 | 78-0063 | APR 80 |
| 147 | F-16A | USAF | 61-60 | 78-0064 | APR 80 |
| 148 | F-16A | BAF | 6H-16 | 78-0131 | APR 80 |
| 149 | F-16A | RNAF | 6K-3 | 78-0274 | APR 80 |
| 150 | F-16A | USAF | 61-61 | 78-0065 | APR 80 |
| 151 | F-16B | USAF | 62-39 | 78-0113 | APR 80 |
| 152 | F-16A | USAF | 61-62 | 78-0066 | APR 80 |
| 153 | F-16A | USAF | 61-63 | 78-0067 | APR 80 |
| 154 | F-16A | USAF | 61-64 | 78-0068 | APR 80 |
| 155 | F-16A | USAF | 61-65 | 78-0069 | MAY 80 |
| 156 | F-16A | RDAF | 6F-3 | 78-0176 | MAY 80 |
| 157 | F-16B | RNAF | 6L-2 | 78-0302 | MAY 80 |
| 158 | F-16B | USAF | 62-40 | 78-0114 | MAY 80 |
| 159 | F-16A | IAF | 6V-2 | 78-0309 | MAY 80 |
| 160 | F-16B | IAF | 6W-5 | 78-0359 | MAY 80 |
| 161 | F-16A | USAF | 61-66 | 78-0070 | MAY 80 |
| 162 | F-16B | RNLAF | 6E-6 | 78-0264 | MAY 80 |
| 163 | F-16A | USAF | 61-67 | 78-0071 | MAY 80 |
| 164 | F-16A | USAF | 61-68 | 78-0072 | MAY 80 |
| 165 | F-16A | BAF | 6H-17 | 78-0132 | MAY 80 |
| 166 | F-16A | USAF | 61-69 | 78-0073 | MAY 80 |
| 167 | F-16B | USAF | 62-41 | 78-0115 | MAY 80 |
| 168 | F-16A | RNLAF | 6D-12 | 78-0223 | MAY 80 |
| 169 | F-16B | IAF | 6W-6 | 78-0360 | MAY 80 |
| 170 | F-16A | USAF | 61-70 | 78-0074 | MAY 80 |
| 171 | F-16A | USAF | 61-71 | 78-0075 | MAY 80 |
| 172 | F-16A | USAF | 61-72 | 78-0076 | MAY 80 |
| 173 | F-16A | USAF | 61-73 | 79-0288 | JUN 80 |
| 174 | F-16B | BAF | 6J-7 | 78-0168 | JUN 80 |
| 175 | F-16A | RNLAF | 6D-13 | 78-0224 | JUN 80 |
| 176 | F-16B | USAF | 62-42 | 79-0410 | JUN 80 |
| 177 | F-16A | IAF | 6V-3 | 78-0310 | JUN 80 |
| 178 | F-16B | IAF | 6W-7 | 78-0361 | JUN 80 |

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|---|---|---|---|---|---|
| 179 | F-16A | USAF | 61-74 | 79-0289 | JUN 80 |
| 180 | F-16A | RNLAF | 6D-14 | 78-0225 | JUN 80 |
| 181 | F-16A | USAF | 61-75 | 79-0290 | JUN 80 |
| 182 | F-16A | USAF | 61-76 | 79-0291 | JUN 80 |
| 183 | F-16A | USAF | 61-77 | 79-0292 | JUN 80 |
| 184 | F-16A | RDAF | 6F-4 | 78-0177 | JUN 80 |
| 185 | F-16B | USAF | 62-43 | 78-0411 | JUN 80 |
| 186 | F-16B | IAF | 6W-8 | 78-0362 | JUN 80 |
| 187 | F-16A | RNAF | 6K-4 | 78-0275 | JUN 80 |
| 188 | F-16A | USAF | 61-78 | 79-0293 | JUN 80 |
| 189 | F-16A | USAF | 61-79 | 79-0294 | JUN 80 |
| 190 | F-16A | USAF | 61-80 | 79-0295 | JUN 80 |
| 191 | F-16A | USAF | 61-81 | 79-0296 | JUN 80 |
| 192 | F-16A | USAF | 61-82 | 79-0297 | JUL 80 |
| 193 | F-16A | BAF | 6H-18 | 78-0133 | JUL 80 |
| 194 | F-16A | RNLAF | 6D-15 | 78-0226 | JUL 80 |
| 195 | F-16B | USAF | 62-44 | 79-0412 | JUL 80 |
| 196 | F-16A | IAF | 6V-4 | 78-0311 | JUL 80 |
| 197 | F-16A | USAF | 61-83 | 79-0298 | JUL 80 |
| 198 | F-16A | USAF | 61-84 | 79-0299 | JUL 80 |
| 199 | F-16A | IAF | 6V-5 | 78-0312 | JUL 80 |
| 200 | F-16A | RNLAF | 6D-16 | 78-0227 | JUL 80 |
| 201 | F-16A | USAF | 61-85 | 79-0300 | JUL 80 |
| 202 | F-16A | USAF | 61-86 | 79-0301 | JUL 80 |
| 203 | F-16B | RDAF | 6G-3 | 78-0206 | JUL 80 |
| 204 | F-16B | USAF | 62-45 | 79-0413 | JUL 80 |
| 205 | F-16A | IAF | 6V-6 | 78-0313 | JUL 80 |
| 206 | F-16A | USAF | 61-87 | 79-0302 | JUL 80 |
| 207 | F-16A | RNAF | 6K-5 | 78-0276 | JUL 80 |
| 208 | F-16A | USAF | 61-88 | 79-0303 | JUL 80 |
| 209 | F-16A | IAF | 6V-7 | 78-0314 | JUL 80 |
| 210 | F-16A | USAF | 61-89 | 79-0304 | JUL 80 |
| 211 | F-16A | USAF | 61-90 | 79-0305 | JUL 80 |
| 212 | F-16A | USAF | 61-91 | 79-0306 | AUG 80 |
| 213 | F-16B | BAF | 6J-8 | 78-0169 | AUG 80 |
| 214 | F-16A | RNLAF | 6D-17 | 78-0228 | AUG 80 |
| 215 | F-16B | USAF | 62-46 | 79-0414 | AUG 80 |
| 216 | F-16A | IAF | 6V-8 | 78-0315 | AUG 80 |
| 217 | F-16A | USAF | 61-92 | 78-0307 | AUG 80 |
| 218 | F-16A | USAF | 61-93 | 79-0308 | AUG 80 |
| 219 | F-16A | IAF | 6V-9 | 78-0316 | AUG 80 |
| 220 | F-16A | RNLAF | 6D-18 | 78-0229 | AUG 80 |
| 221 | F-16A | USAF | 61-94 | 79-0309 | AUG 80 |
| 222 | F-16A | USAF | 61-95 | 79-0310 | AUG 80 |
| 223 | F-16A | RDAF | 6F-5 | 78-0178 | AUg 80 |
| 224 | F-16B | USAF | 62-47 | 79-0415 | AUG 80 |
| 225 | F-16A | IAF | 6V-10 | 78-0317 | AUG 80 |
| 226 | F-16A | USAF | 61-96 | 79-0311 | AUG 80 |
| 227 | F-16A | RNAF | 6K-6 | 78-0277 | AUG 80 |
| 228 | F-16A | USAF | 61-97 | 79-0312 | AUG 80 |
| 229 | F-16A | IAF | 6V-11 | 78-0318 | AUG 80 |
| 230 | F-16A | USAF | 61-98 | 79-0313 | AUG 80 |
| 231 | F-16A | USAF | 61-99 | 79-0314 | AUG 80 |
| 232 | F-16A | USAF | 61-100 | 79-0315 | SEP 80 |
| 233 | F-16B | RDAF | 6G-4 | 78-0207 | SEP 80 |
| 234 | F-16B | RNAF | 6L-3 | 78-0303 | SEP 80 |
| 235 | F-16B | USAF | 62-48 | 79-0416 | SEP 80 |
| 236 | F-16A | IAF | 6V-12 | 78-0319 | SEP 80 |
| 237 | F-16A | USAF | 61-101 | 79-0316 | SEP 80 |
| 238 | F-16A | USAF | 61-102 | 79-0317 | SEP 80 |
| 239 | F-16A | IAF | 6V-13 | 78-0320 | SEP 80 |
| 240 | F-16A | BAF | 6H-19 | 78-0134 | SEP 80 |
| 241 | F-16A | RNLAF | 6D-19 | 78-0230 | SEP 80 |
| 242 | F-16A | USAF | 61-103 | 79-0318 | SEP 80 |
| 243 | F-16A | USAF | 61-104 | 79-0319 | SEP 80 |
| 244 | F-16A | USAF | 61-105 | 79-0320 | SEP 80 |
| 245 | F-16B | USAF | 62-49 | 79-0417 | SEP 80 |
| 246 | F-16A | IAF | 6V-14 | 78-0321 | SEP 80 |
| 247 | F-16A | RDAF | 6F-6 | 78-0179 | SEP 80 |
| 248 | F-16A | RNLAF | 6D-20 | 78-0231 | SEP 80 |
| 249 | F-16A | USAF | 61-106 | 79-0321 | SEP 80 |
| 250 | F-16A | USAF | 61-107 | 79-0322 | SEP 80 |
| 251 | F-16A | IAF | 6V-15 | 78-0322 | SEP 80 |
| 252 | F-16A | USAF | 61-108 | 79-0323 | SEP 80 |
| 253 | F-16A | USAF | 61-109 | 79-0324 | SEP 80 |
| 254 | F-16A | USAF | 61-110 | 79-0325 | OCT 80 |
| 255 | F-16B | BAF | 6J-9 | 78-0170 | OCT 80 |
| 256 | F-16A | RNLAF | 6D-21 | 78-0232 | OCT 80 |
| 257 | F-16B | USAF | 62-50 | 79-0418 | OCT 80 |
| 258 | F-16A | IAF | 6V-16 | 78-0323 | OCT 80 |
| 259 | F-16A | USAF | 61-111 | 79-0326 | OCT 80 |
| 260 | F-16A | USAF | 61-112 | 79-0327 | OCT 80 |
| 261 | F-16A | IAF | 6V-17 | 78-0324 | OCT 80 |
| 262 | F-16A | RDAF | 6F-7 | 78-0180 | OCT 80 |
| 263 | F-16A | RNLAF | 6D-22 | 78-0233 | OCT 80 |
| 264 | F-16A | USAF | 61-113 | 79-0328 | OCT 80 |
| 265 | F-16A | USAF | 61-114 | 79-0329 | OCT 80 |
| 266 | F-16A | USAF | 61-115 | 79-0330 | OCT 80 |
| 267 | F-16B | USAF | 62-51 | 79-0419 | OCT 80 |
| 268 | F-16A | IAF | 6V-18 | 78-0325 | OCT 80 |
| 269 | F-16A | RDAF | 6F-8 | 78-0181 | OCT 80 |
| 270 | F-16A | RNAF | 6K-7 | 78-0278 | OCT 80 |
| 271 | F-16A | USAF | 61-116 | 79-0331 | OCT 80 |
| 272 | F-16A | USAF | 61-117 | 79-0332 | OCT 80 |
| 273 | F-16A | IAF | 6V-19 | 78-0326 | OCT 80 |
| 274 | F-16A | USAF | 61-118 | 79-0333 | OCT 80 |
| 275 | F-16A | USAF | 61-119 | 79-0334 | OCT 80 |
| 276 | F-16A | USAF | 61-120 | 79-0335 | NOV 80 |
| 277 | F-16B | RDAF | 6G-5 | 78-0208 | NOV 80 |
| 278 | F-16B | RNLAF | 6E-7 | 78-0265 | NOV 80 |
| 279 | F-16B | USAF | 62-52 | 79-0420 | NOV 80 |
| 280 | F-16A | IAF | 6V-20 | 78-0327 | NOV 80 |
| 281 | F-16A | USAF | 61-121 | 79-0336 | NOV 80 |
| 282 | F-16A | USAF | 61-122 | 79-0337 | NOV 80 |
| 283 | F-16A | IAF | 6V-21 | 78-0328 | NOV 80 |
| 284 | F-16A | BAF | 6H-20 | 78-0135 | NOV 80 |
| 285 | F-16A | RNAF | 6K-8 | 78-0279 | NOV 80 |
| 286 | F-16A | USAF | 61-123 | 79-0338 | NOV 80 |
| 287 | F-16A | USAF | 61-124 | 79-0339 | NOV 80 |
| 288 | F-16A | USAF | 61-125 | 79-0340 | NOV 80 |
| 289 | F-16A | IAF | 6V-22 | 78-0329 | NOV 80 |
| 290 | F-16A | USAF | 61-126 | 79-0341 | NOV 80 |
| 291 | F-16A | RDAF | 6F-9 | 78-0182 | NOV 80 |
| 292 | F-16A | RNAF | 6K-9 | 78-0280 | NOV 80 |
| 293 | F-16A | USAF | 61-127 | 79-0342 | NOV 80 |
| 294 | F-16A | USAF | 61-128 | 79-0343 | NOV 80 |
| 295 | F-16A | IAF | 6V-23 | 78-0330 | NOV 80 |
| 296 | F-16A | USAF | 61-129 | 79-0344 | NOV 80 |
| 297 | F-16A | USAF | 61-130 | 79-0345 | NOV 80 |
| 298 | F-16A | USAF | 61-131 | 79-0346 | DEC 80 |
| 299 | F-16A | BAF | 6H-21 | 78-0136 | DEC 80 |
| 300 | F-16A | RNLAF | 6D-23 | 78-0234 | DEC 80 |
| 301 | F16B | USAF | 62-53 | 79-0421 | DEC 80 |
| 302 | F-16A | IAF | 6V-24 | 78-0331 | DEC 80 |
| 303 | F-16A | USAF | 61-132 | 79-0347 | DEC 80 |
| 304 | F-16A | USAF | 61-133 | 79-0348 | DEC 80 |
| 305 | F-16A | IAF | 6V-25 | 78-0332 | DEC 80 |
| 306 | F-16A | RDAF | 6F-10 | 78-0183 | DEC 80 |
| 307 | F-16A | RNAF | 6K-10 | 78-0281 | DEC 80 |
| 308 | F-16A | USAF | 61-134 | 79-0349 | DEC 80 |
| 309 | F-16A | USAF | 61-135 | 79-0350 | DEC 80 |
| 310 | F-16A | USAF | 61-136 | 79-0351 | DEC 80 |
| 311 | F-16B | USAF | 62-54 | 79-0422 | DEC 80 |
| 312 | F-16A | IAF | 6V-26 | 78-0333 | DEC 80 |
| 313 | F-16A | RDAF | 6F-11 | 78-0184 | DEC 80 |
| 314 | F-16A | RNAF | 6K-11 | 78-0282 | DEC 80 |
| 315 | F-16A | USAF | 61-137 | 79-0352 | DEC 80 |
| 316 | F-16A | USAF | 61-138 | 79-0353 | DEC 80 |
| 317 | F-16A | IAF | 6V-27 | 78-0334 | DEC 80 |
| 318 | F-16A | USAF | 61-139 | 79-0354 | DEC 80 |
| 319 | F-16A | USAF | 61-140 | 79-0355 | DEC 80 |
| 320 | F-16A | USAF | 61-141 | 79-0356 | JAN 81 |
| 321 | F-16A | BAF | 6H-22 | 78-0137 | JAN 81 |
| 322 | F-16A | RNLAF | 6D-24 | 78-0235 | JAN 81 |
| 323 | F-16B | USAF | 62-55 | 79-0423 | JAN 81 |
| 324 | F-16A | IAF | 6V-28 | 78-0335 | JAN 81 |
| 325 | F-16A | USAF | 61-142 | 79-0357 | JAN 81 |
| 326 | F-16A | USAF | 61-143 | 79-0358 | JAN 81 |
| 327 | F-16A | IAF | 6V-29 | 78-0336 | JAN 81 |
| 328 | F-16A | RDAF | 6F-12 | 78-0185 | JAN 81 |
| 329 | F-16A | RNLAF | 6D-25 | 78-0236 | JAN 81 |
| 330 | F-16A | USAF | 61-144 | 79-0359 | JAN 81 |
| 331 | F-16A | USAF | 61-145 | 79-0360 | JAN 81 |
| 332 | F-16A | USAF | 61-146 | 79-0361 | JAN 81 |
| 333 | F-16B | USAF | 62-56 | 79-0424 | JAN 81 |
| 334 | F-16A | IAF | 6V-30 | 78-0337 | JAN 81 |
| 335 | F-16A | BAF | 6H-23 | 78-0138 | JAN 81 |
| 336 | F-16A | RNAF | 6K-12 | 78-0283 | JAN 81 |
| 337 | F-16A | USAF | 61-147 | 79-0362 | JAN 81 |
| 338 | F-16A | USAF | 61-148 | 79-0363 | JAN 81 |
| 339 | F-16A | IAF | 6V-31 | 78-0338 | JAN 81 |
| 340 | F-16A | USAF | 61-149 | 79-0364 | JAN 81 |
| 341 | F-16A | USAF | 61-150 | 79-0365 | JAN 81 |
| 342 | F-16A | USAF | 61-151 | 79-0366 | FEB 81 |
| 343 | F-16B | BAF | 6J-10 | 78-0171 | FEB 81 |
| 344 | F-16B | RNLAF | 6E-8 | 78-0266 | FEB 81 |
| 345 | F-16B | USAF | 62-57 | 79-0425 | FEB 81 |
| 346 | F-16A | IAF | 6V-32 | 78-0339 | FEB 81 |
| 347 | F-16A | USAF | 61-152 | 79-0367 | FEB 81 |
| 348 | F-16A | USAF | 61-153 | 79-0368 | FEB 81 |
| 349 | F-16A | IAF | 6V-33 | 78-0340 | FEB 81 |
| 350 | F-16A | RDAF | 6F-13 | 78-0186 | FEB 81 |
| 351 | F-16A | RNAF | 6K-13 | 78-0284 | FEB 81 |
| 352 | F-16A | USAF | 61-154 | 79-0369 | FEB 81 |
| 353 | F-16A | USAF | 61-155 | 79-0370 | FEB 81 |
| 354 | F-16A | USAF | 61-156 | 79-0371 | FEB 81 |
| 355 | F-16B | USAF | 62-58 | 79-0426 | FEB 81 |
| 356 | F-16A | IAF | 6V-34 | 78-0341 | FEB 81 |
| 357 | F-16A | USAF | 61-157 | 79-0372 | FEB 81 |
| 358 | F-16A | BAF | 6H-24 | 78-0139 | FEB 81 |
| 359 | F-16A | RNLAF | 6D-26 | 78-0237 | FEB 81 |
| 360 | F-16A | USAF | 61-158 | 79-0373 | FEB 81 |
| 361 | F-16A | USAF | 61-159 | 79-0374 | FEB 81 |
| 362 | F-16A | IAF | 6V-35 | 78-0342 | FEB 81 |
| 363 | F-16A | USAF | 61-160 | 79-0375 | FEB 81 |
| 364 | F-16A | USAF | 61-161 | 79-0376 | FEB 81 |
| 365 | F-16A | USAF | 61-162 | 79-0377 | MAR 81 |
| 366 | F-16A | RDAF | 6F-14 | 78-0187 | MAR 81 |
| 367 | F-16B | RNAF | 6L-4 | 78-0304 | MAR 81 |
| 368 | F-16B | USAF | 62-59 | 79-0427 | MAR 81 |
| 369 | F-16A | IAF | 6V-36 | 78-0343 | MAR 81 |
| 370 | F-16A | USAF | 61-163 | 79-0378 | MAR 81 |
| 371 | F-16A | USAF | 61-164 | 79-0379 | MAR 81 |
| 372 | F-16A | IAF | 6V-37 | 78-0344 | MAR 81 |
| 373 | F-16A | BAF | 6H-25 | 78-0140 | MAR 81 |
| 374 | F-16A | RNLAF | 6D-27 | 78-0238 | MAR 81 |
| 375 | F-16A | USAF | 61-165 | 79-0380 | MAR 81 |
| 376 | F-16A | USAF | 61-166 | 79-0381 | MAR 81 |
| 377 | F-16A | USAF | 61-167 | 79-0382 | MAR 81 |
| 378 | F-16B | USAF | 62-60 | 79-0428 | MAR 81 |
| 379 | F-16A | IAF | 6V-38 | 78-0345 | MAR 81 |
| 380 | F-16A | USAF | 61-168 | 79-0383 | MAR 81 |
| 381 | F-16A | RDAF | 6F-15 | 78-0188 | MAR 81 |
| 382 | F-16A | RNLAF | 6D-28 | 78-0239 | MAR 81 |
| 383 | F-16A | USAF | 61-169 | 79-0384 | MAR 81 |
| 384 | F-16A | USAF | 61-170 | 79-0385 | MAR 81 |
| 385 | F-16A | IAF | 6V-39 | 78-0346 | MAR 81 |
| 386 | F-16A | USAF | 61-171 | 79-0386 | MAR 81 |
| 387 | F-16A | USAF | 61-172 | 79-0387 | MAR 81 |
| 388 | F-16A | USAF | 61-173 | 79-0388 | APR 81 |
| 389 | F-16A | BAF | 6H-26 | 78-0141 | APR 81 |
| 390 | F-16A | RNAF | 6K-14 | 78-0285 | APR 81 |
| 391 | F-16B | USAF | 62-61 | 79-0429 | APR 81 |
| 392 | F-16A | IAF | 6V-40 | 78-0347 | APR 81 |
| 393 | F-16A | USAF | 61-174 | 79-0389 | APR 81 |
| 394 | F-16A | USAF | 61-175 | 79-0390 | APR 81 |
| 395 | F-16A | IAF | 6V-41 | 78-0348 | APR 81 |
| 396 | F-16A | RDAF | 6F-16 | 78-0189 | APR 81 |
| 397 | F-16A | RNAF | 6K-15 | 78-0286 | APR 81 |
| 398 | F-16A | USAF | 61-176 | 79-0391 | APR 81 |
| 399 | F-16A | USAF | 61-177 | 79-0392 | APR 81 |
| 400 | F-16A | USAF | 61-178 | 79-0393 | APR 81 |
| 401 | F-16B | USAF | 62-62 | 79-0430 | APR 81 |
| 402 | F-16A | IAF | 6V-42 | 78-0349 | APR 81 |
| 403 | F-16A | USAF | 61-179 | 79-0394 | APR 81 |
| 404 | F-16A | RDAF | 6F-17 | 78-0190 | APR 81 |
| 405 | F-16A | RNLAF | 6D-29 | 78-0240 | APR 81 |
| 406 | F-16A | USAF | 61-180 | 79-0395 | APR 81 |
| 407 | F-16A | USAF | 61-181 | 79-0396 | APR 81 |
| 408 | F-16A | IAF | 6V-43 | 78-0350 | APR 81 |
| 409 | F-16A | USAF | 61-182 | 79-0397 | APR 81 |
| 410 | F-16A | USAF | 61-183 | 79-0398 | APR 81 |
| 411 | F-16A | USAF | 61-184 | 79-0399 | MAY 81 |
| 412 | F-16A | BAF | 6H-27 | 78-0142 | MAY 81 |
| 413 | F-16B | RNLAF | 6E-9 | 78-0267 | MAY 81 |
| 414 | F-16B | USAF | 62-63 | 79-0431 | MAY 81 |
| 415 | F-16A | IAF | 6V-44 | 78-0351 | MAY 81 |
| 416 | F-16A | USAF | 61-185 | 79-0400 | MAY 81 |
| 417 | F-16A | USAF | 61-186 | 79-0401 | MAY 81 |
| 418 | F-16A | IAF | 6V-45 | 78-0352 | MAY 81 |
| 419 | F-16B | RDAF | 6G-6 | 78-0209 | MAY 81 |
| 420 | F-16A | RNAF | 6K-16 | 78-0287 | MAY 81 |
| 421 | F-16A | USAF | 61-187 | 79-0402 | MAY 81 |
| 422 | F-16A | USAF | 61-188 | 79-0403 | MAY 81 |
| 423 | F-16A | USAF | 61-189 | 79-0404 | MAY 81 |
| 424 | F-16B | USAF | 62-64 | 79-0432 | MAY 81 |
| 425 | F-16A | IAF | 6V-46 | 78-0353 | MAY 81 |
| 426 | F-16A | USAF | 61-190 | 79-0405 | MAY 81 |
| 427 | F-16A | RDAF | 6F-18 | 78-0191 | MAY 81 |
| 428 | F-16A | RNLAF | 6D-30 | 78-0241 | MAY 81 |
| 429 | F-16A | USAF | 61-191 | 79-0406 | MAY 81 |
| 430 | F-16A | USAF | 61-192 | 79-0407 | MAY 81 |
| 431 | F-16B | IAF | 6V-47 | 78-0354 | MAY 81 |
| 432 | F-16A | USAF | 61-193 | 79-0408 | MAY 81 |
| 433 | F-16A | USAF | 61-194 | 79-0409 | MAY 81 |
| 434 | F-16A | USAF | 61-195 | 80-0474 | JUN 81 |
| 435 | F-16A | BAF | 6H-28 | 78-0143 | JUN 81 |
| 436 | F-16A | RNAF | 6K-17 | 78-0288 | JUN 81 |
| 437 | F-16B | USAF | 62-65 | 80-0623 | JUN 81 |
| 438 | F-16A | IAF | 6V-48 | 80-0649 | JUN 81 |
| 439 | F-16A | USAF | 61-196 | 80-0475 | JUN 81 |

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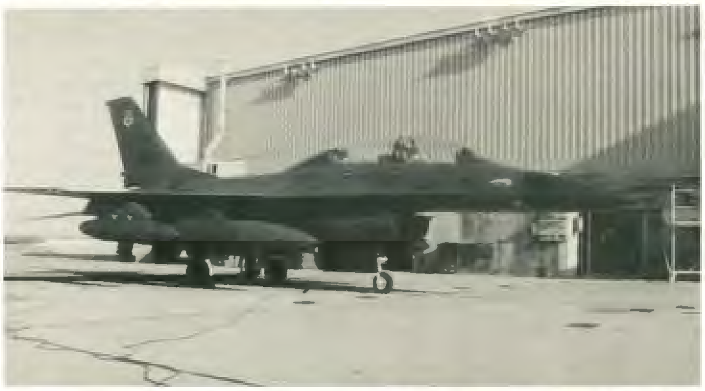
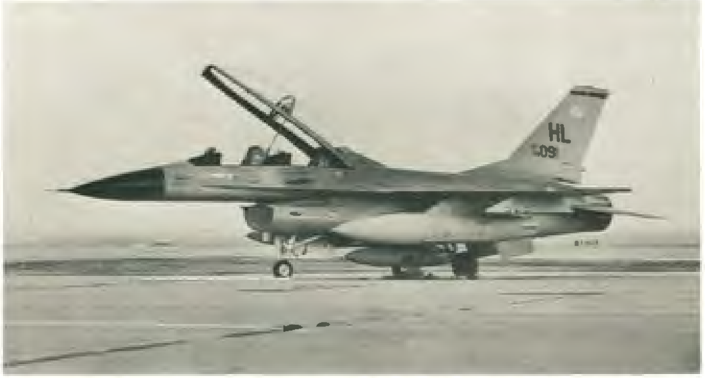
|---|---|---|---|---|---|
| 440 | F-16A | USAF | 61-197 | 80-0476 | JUN 81 |
| 441 | F-16A | IAF | 6V-49 | 80-0650 | JUN 81 |
| 442 | F-16A | RDAF | 6F-19 | 78-0192 | JUN 81 |
| 443 | F-16A | RNAF | 6K-18 | 78-0289 | JUN 81 |
| 444 | F-16A | USAF | 61-198 | 80-0477 | JUN 81 |
| 445 | F-16A | USAF | 61-199 | 80-0478 | JUN 81 |
| 446 | F-16A | USAF | 61-200 | 80-0479 | JUN 81 |
| 447 | F-16B | USAF | 62-66 | 80-0624 | JUN 81 |
| 448 | F-16A | IAF | 6V-50 | 80-0651 | JUN 81 |
| 449 | F-16A | USAF | 61-201 | 80-0480 | JUN 81 |
| 450 | F-16A | RDAF | 6F-20 | 78-0193 | JUN 81 |
| 451 | F-16A | RNLAF | 6K-31 | 78-0242 | JUN 81 |
| 452 | F-16A | USAF | 61-202 | 80-0481 | JUN 81 |
| 453 | F-16A | USAF | 61-203 | 80-0482 | JUN 81 |
| 454 | F-16A | IAF | 6V-51 | 80-0652 | JUN 81 |
| 455 | F-16A | USAF | 61-204 | 80-0483 | JUN 81 |
| 456 | F-16A | USAF | 61-205 | 80-0484 | JUN 81 |
| 457 | F-16A | USAF | 61-206 | 80-0485 | JUL 81 |
| 458 | F-16A | BAF | 6H-29 | 78-0144 | JUL 81 |
| 459 | F-16B | RNAF | 6L-5 | 78-0305 | JUL 81 |
| 460 | F-16B | USAF | 62-67 | 80-0625 | JUL 81 |
| 461 | F-16A | IAF | 6V-52 | 80-0653 | JUL 81 |
| 462 | F-16A | USAF | 61-207 | 80-0486 | JUL 81 |
| 463 | F-16A | USAF | 61-208 | 80-0487 | JUL 81 |
| 464 | F-16A | USAF | 61-209 | 80-0488 | JUL 81 |
| 465 | F-16A | IAF | 6V-53 | 80-0654 | JUL 81 |
| 466 | F-16A | BAF | 6H-30 | 78-0145 | JUL 81 |
| 467 | F-16A | RNLAF | 6D-32 | 78-0243 | JUL 81 |
| 468 | F-16A | USAF | 61-210 | 80-0489 | JUL 81 |
| 469 | F-16A | USAF | 61-211 | 80-0490 | JUL 81 |
| 470 | F-16A | USAF | 61-212 | 80-0491 | JUL 81 |
| 471 | F-16B | USAF | 62-68 | 80-0626 | JUL 81 |
| 472 | F-16A | IAF | 6V-54 | 80-0655 | JUL 81 |
| 473 | F-16A | USAF | 61-213 | 80-0492 | JUL 81 |
| 474 | F-16A | RDAF | 6F-21 | 78-0194 | JUL 81 |
| 475 | F-16A | RNLAF | 6D-33 | 78-0244 | JUL 81 |
| 476 | F-16A | USAF | 61-214 | 80-0493 | JUL 81 |
| 477 | F-16A | USAF | 61-215 | 80-0494 | JUL 81 |
| 478 | F-16A | IAF | 6V-55 | 80-0656 | JUL 81 |
| 479 | F-16A | USAF | 61-216 | 80-0495 | JUL 81 |
| 480 | F-16A | USAF | 61-217 | 80-0496 | JUL 81 |
| 481 | F-16A | USAF | 61-218 | 80-0497 | AUG 81 |
| 482 | F-16A | BAF | 6H-31 | 78-0146 | AUG 81 |
| 483 | F-16B | RNLAF | 6E-10 | 78-0268 | AUG 81 |
| 484 | F-16B | USAF | 62-69 | 80-0627 | AUG 81 |
| 485 | F-16A | IAF | 6V-56 | 80-0657 | AUG 81 |
| 486 | F-16A | USAF | 61-219 | 80-0498 | AUG 81 |
| 487 | F-16A | USAF | 61-220 | 80-0499 | AUG 81 |
| 488 | F-16A | USAF | 61-221 | 80-0500 | AUG 81 |
| 489 | F-16A | IAF | 6V-57 | 80-0658 | AUG 81 |
| 490 | F-16A | RDAF | 6F-22 | 78-0195 | AUG 81 |
| 491 | F-16A | RNAF | 6K-19 | 78-0290 | AUG 81 |
| 492 | F-16A | USAF | 61-222 | 80-0501 | AUG 81 |
| 493 | F-16A | USAF | 61-223 | 80-0502 | AUG 81 |
| 494 | F-16A | USAF | 61-224 | 80-0503 | AUG 81 |
| 495 | F-16B | USAF | 62-70 | 80-0628 | AUG 81 |
| 496 | F-16A | IAF | 6V-58 | 80-0659 | AUG 81 |
| 497 | F-16A | USAF | 61-225 | 80-0504 | AUG 81 |
| 498 | F-16B | BAF | 6J-11 | 78-0172 | AUG 81 |
| 499 | F-16A | RNLAF | 6D-34 | 78-0245 | AUG 81 |
| 500 | F-16A | USAF | 61-226 | 80-0505 | AUG 81 |
| 501 | F-16A | USAF | 61-227 | 80-0506 | AUG 81 |
| 502 | F-16A | IAF | 6V-59 | 80-0660 | AUG 81 |
| 503 | F-16A | USAF | 61-228 | 80-0507 | AUG 81 |
| 504 | F-16A | USAF | 61-229 | 80-0508 | AUG 81 |
| 505 | F-16A | USAF | 61-230 | 80-0509 | SEP 81 |
| 506 | F-16A | RDAF | 6F-23 | 78-0196 | SEP 81 |
| 507 | F-16A | RNLAF | 6D-35 | 78-0246 | SEP 81 |
| 508 | F-16B | USAF | 62-71 | 80-0629 | SEP 81 |
| 509 | F-16A | IAF | 6V-60 | 80-0661 | SEP 81 |
| 510 | F-16A | USAF | 61-231 | 80-0510 | SEP 81 |
| 511 | F-16A | USAF | 61-232 | 80-0511 | SEP 81 |
| 512 | F-16A | USAF | 61-233 | 80-0512 | SEP 81 |
| 513 | F-16A | IAF | 6V-61 | 80-0662 | SEP 81 |
| 514 | F-16A | BAF | 6H-32 | 78-0147 | SEP 81 |
| 515 | F-16A | RNAF | 6K-20 | 78-0291 | SEP 81 |
| 516 | F-16A | USAF | 61-234 | 80-0513 | SEP 81 |
| 517 | F-16A | USAF | 61-235 | 80-0514 | SEP 81 |
| 518 | F-16A | USAF | 61-236 | 80-0515 | SEP 81 |
| 519 | F-16B | USAF | 62-72 | 80-0630 | SEP 81 |
| 520 | F-16A | IAF | 6V-62 | 80-0663 | SEP 81 |
| 521 | F-16A | USAF | 61-237 | 80-0516 | SEP 81 |
| 522 | F-16A | BAF | 6H-33 | 78-0148 | SEP 81 |
| 523 | F-16A | RNAF | 6K-21 | 78-0292 | SEP 81 |
| 524 | F-16A | USAF | 61-238 | 80-0517 | SEP 81 |
| 525 | F-16A | USAF | 61-239 | 80-0518 | SEP 81 |
| 526 | F-16A | IAF | 6V-63 | 80-0664 | SEP 81 |
| 527 | F-16A | USAF | 61-240 | 80-0519 | SEP 81 |
| 528 | F-16A | USAF | 61-241 | 80-0520 | SEP 81 |
| 529 | F-16A | USAF | 61-242 | 80-0521 | OCT 81 |
| 530 | F-16B | RDAF | 6G-7 | 78-0210 | OCT 81 |
| 531 | F-16A | RNLAF | 6D-36 | 78-0247 | OCT 81 |
| 532 | F-16B | USAF | 62-73 | 80-0631 | OCT 81 |
| 533 | F-16A | IAF | 6V-64 | 80-0665 | OCT 81 |
| 534 | F-16A | USAF | 61-243 | 80-0522 | OCT 81 |
| 535 | F-16A | USAF | 61-244 | 80-0523 | OCT 81 |
| 536 | F-16A | USAF | 61-245 | 80-0524 | OCT 81 |
| 537 | F-16A | IAF | 6V-65 | 80-0666 | OCT 81 |
| 538 | F-16A | BAF | 6H-34 | 78-0149 | OCT 81 |
| 539 | F-16A | RNAF | 6K-22 | 78-0293 | OCT 81 |
| 540 | F-16A | USAF | 61-246 | 80-0525 | OCT 81 |
| 541 | F-16A | USAF | 61-247 | 80-0526 | OCT 81 |
| 542 | F-16A | USAF | 61-248 | 80-0527 | OCT 81 |
| 543 | F-16B | USAF | 62-74 | 80-0632 | OCT 81 |
| 544 | F-16A | IAF | 6V-66 | 80-0667 | OCT 81 |
| 545 | F-16A | USAF | 61-249 | 80-0528 | OCT 81 |
| 546 | F-16A | BAF | 6H-35 | 78-0150 | OCT 81 |
| 547 | F-16A | RNLAF | 6D-37 | 78-0248 | OCT 81 |
| 548 | F-16A | USAF | 61-250 | 80-0529 | OCT 81 |
| 549 | F-16A | USAF | 61-251 | 80-0530 | OCT 81 |
| 550 | F-16A | IAF | 6V-67 | 80-0668 | OCT 81 |
| 551 | F-16A | USAF | 61-252 | 80-0531 | OCT 81 |
| 552 | F-16A | USAF | 61-253 | 80-0532 | OCT 81 |
| 553 | F-16A | USAF | 61-254 | 80-0533 | OCT 81 |
| 554 | F-16A | USAF | 61-255 | 80-0534 | NOV 81 |
| 555 | F-16A | RDAF | 6F-24 | 78-0197 | NOV 81 |
| 556 | F-16A | RNLAF | 6D-38 | 78-0249 | NOV 81 |
| 557 | F-16B | USAF | 62-75 | 80-0633 | NOV 81 |
| 558 | F-16A | USAF | 61-256 | 80-0535 | NOV 81 |
| 559 | F-16A | USAF | 61-257 | 80-0536 | NOV 81 |
| 560 | F-16A | RNLAF | 6D-39 | 78-0250 | NOV 81 |
| 561 | F-16A | USAF | 61-258 | 80-0537 | NOV 81 |
| 562 | F-16A | USAF | 61-259 | 80-0538 | NOV 81 |
| 563 | F-16A | BAF | 6H-36 | 78-0151 | NOV 81 |
| 564 | F-16A | USAF | 61-260 | 80-0539 | NOV 81 |
| 565 | F-16A | USAF | 61-261 | 80-0540 | NOV 81 |
| 566 | F-16B | RNAF | 6L-6 | 78-0306 | NOV 81 |
| 567 | F-16B | USAF | 62-76 | 80-0634 | NOV 81 |
| 568 | F-16A | USAF | 61-262 | 80-0541 | NOV 81 |
| 569 | F-16A | USAF | 61-263 | 80-0542 | NOV 81 |
| 570 | F-16A | BAF | 6H-37 | 78-0152 | NOV 81 |
| 571 | F-16A | USAF | 61-264 | 80-0543 | NOV 81 |
| 572 | F-16B | RNLAF | 6E-11 | 78-0269 | NOV 81 |
| 573 | F-16A | USAF | 61-265 | 80-0544 | NOV 81 |
| 574 | F-16A | USAF | 61-266 | 80-0545 | NOV 81 |
| 575 | F-16A | USAF | 61-267 | 80-0546 | NOV 81 |
| 576 | F-16A | USAF | 61-268 | 80-0547 | DEC 81 |
| 577 | F-16A | RDAF | 6F-25 | 78-0198 | DEC 81 |
| 578 | F-16A | RNLAF | 6D-40 | 78-0251 | DEC 81 |
| 579 | F-16B | USAF | 62-77 | 80-0635 | DEC 81 |
| 580 | F-16A | USAF | 61-269 | 80-0548 | DEC 81 |
| 581 | F-16A | USAF | 61-270 | 80-0549 | DEC 81 |
| 582 | F-16A | USAF | 61-271 | 80-0550 | DEC 81 |
| 583 | F-16A | USAF | 61-272 | 80-0551 | DEC 81 |
| 584 | F-16A | RNAF | 6K-23 | 78-0294 | DEC 81 |
| 585 | F-16A | USAF | 61-273 | 80-0552 | DEC 81 |
| 586 | F-16A | USAF | 61-274 | 80-0553 | DEC 81 |
| 587 | F-16A | BAF | 6H-38 | 78-0153 | DEC 81 |
| 588 | F-16B | USAF | 62-78 | 80-0636 | DEC 81 |
| 589 | F-16A | USAF | 61-275 | 80-0554 | DEC 81 |
| 590 | F-16A | USAF | 61-276 | 80-0555 | DEC 81 |
| 591 | F-16A | RNAF | 6K-24 | 78-0295 | DEC 81 |
| 592 | F-16A | USAF | 61-277 | 80-0556 | DEC 81 |
| 593 | F-16A | USAF | 61-278 | 80-0557 | DEC 81 |
| 594 | F-16A | USAF | 61-279 | 80-0558 | DEC 81 |
| 595 | F-16A | USAF | 61-280 | 80-0559 | DEC 81 |
| 596 | F-16A | USAF | 61-281 | 80-0560 | JAN 82 |
| 597 | F-16A | BAF | 6H-39 | 78-0154 | JAN 82 |
| 598 | F-16A | RNLAF | 6D-41 | 78-0252 | JAN 82 |
| 599 | F-16A | EAF | 9E-1 | 80-0639 | JAN 82 |
| 600 | F-16B | EAF | 9F-1 | 80-0644 | JAN 82 |
| 601 | F-16A | USAF | 61-282 | 80-0561 | JAN 82 |
| 602 | F-16A | USAF | 61-283 | 80-0562 | JAN 82 |
| 603 | F-16A | USAF | 61-284 | 80-0563 | JAN 82 |
| 604 | F-16A | RDAF | 6F-26 | 78-0199 | JAN 82 |
| 605 | F-16A | RNLAF | 6D-42 | 78-0253 | JAN 82 |
| 606 | F-16A | USAF | 61-285 | 80-0564 | JAN 82 |
| 607 | F-16A | USAF | 61-286 | 80-0565 | JAN 82 |
| 608 | F-16A | USAF | 61-287 | 80-0566 | JAN 82 |
| 609 | F-16B | EAF | 9F-2 | 80-0645 | JAN 82 |
| 610 | F-16A | USAF | 61-288 | 80-0567 | JAN 82 |
| 611 | F-16A | BAF | 6H-40 | 78-0155 | JAN 82 |
| 612 | F-16A | RNAF | 6K-25 | 78-0296 | JAN 82 |
| 613 | F-16A | USAF | 61-289 | 80-0568 | JAN 82 |
| 614 | F-16A | USAF | 61-290 | 80-0569 | JAN 82 |
| 615 | F-16A | USAF | 61-291 | 80-0570 | JAN 82 |
| 616 | F-16A | USAF | 61-292 | 80-0571 | JAN 82 |
| 617 | F-16A | USAF | 61-293 | 80-0572 | FEB 82 |
| 618 | F-16A | BAF | 6H-41 | 78-0156 | FEB 82 |
| 619 | F-16A | RNLAF | 6D-43 | 78-0254 | FEB 82 |
| 620 | F-16A | EAF | 9E-2 | 80-0640 | FEB 82 |
| 621 | F-16B | EAF | 9F-3 | 80-0646 | FEB 82 |
| 622 | F-16A | USAF | 61-294 | 80-0573 | FEB 82 |
| 623 | F-16A | USAF | 61-295 | 80-0574 | FEB 82 |
| 624 | F-16A | USAF | 61-296 | 80-0575 | FEB 82 |
| 625 | F-16B | RDAF | 6G-8 | 78-0211 | FEB 82 |
| 626 | F-16B | RNLAF | 6E-12 | 78-0270 | FEB 82 |
| 627 | F-16A | USAF | 61-297 | 80-0576 | FEB 82 |
| 628 | F-16A | USAF | 61-298 | 80-0577 | FEB 82 |
| 629 | F-16A | USAF | 61-299 | 80-0578 | FEB 82 |
| 630 | F-16B | EAF | 9F-4 | 80-0647 | FEB 82 |
| 631 | F-16A | USAF | 61-300 | 80-0579 | FEB 82 |
| 632 | F-16A | BAF | 6H-42 | 78-0157 | FEB 82 |
| 633 | F-16A | RNAF | 6K-26 | 78-0297 | FEB 82 |
| 634 | F-16A | USAF | 61-301 | 80-0580 | FEB 82 |
| 635 | F-16A | USAF | 61-302 | 80-0581 | FEB 82 |
| 636 | F-16A | USAF | 61-303 | 80-0582 | FEB 82 |
| 637 | F-16A | USAF | 61-304 | 80-0583 | FEB 82 |
| 638 | F-16A | USAF | 61-305 | 80-0584 | MAR 82 |
| 639 | F-16A | BAF | 6H-43 | 78-0158 | MAR 82 |
| 640 | F-16A | RNLAF | 6D-44 | 78-0255 | MAR 82 |
| 641 | F-16B | USAF | 62-79 | 80-0637 | MAR 82 |
| 642 | F-16A | EAF | 9E-3 | 80-0641 | MAR 82 |
| 643 | F-16A | USAF | 61-306 | 80-0585 | MAR 82 |
| 644 | F-16A | USAF | 61-307 | 80-0586 | MAR 82 |
| 645 | F-16A | USAF | 61-308 | 80-0587 | MAR 82 |
| 646 | F-16A | RDAF | 6F-27 | 78-0200 | MAR 82 |
| 647 | F-16A | RNAF | 6K-27 | 78-0298 | MAR 82 |
| 648 | F-16A | USAF | 61-309 | 80-0588 | MAR 82 |
| 649 | F-16A | USAF | 61-310 | 80-0589 | MAR 82 |
| 650 | F-16A | USAF | 61-311 | 80-0590 | MAR 82 |
| 651 | F-16A | USAF | 61-312 | 80-0591 | MAR 82 |
| 652 | F-16A | USAF | 61-313 | 80-0592 | MAR 82 |
| 653 | F-16B | BAF | 6J-12 | 78-0173 | MAR 82 |
| 654 | F-16A | RNAF | 6K-28 | 78-0299 | MAR 82 |
| 655 | F-16A | USAF | 61-314 | 80-0593 | MAR 82 |
| 656 | F-16A | USAF | 61-315 | 80-0594 | MAR 82 |
| 657 | F-16A | USAF | 61-316 | 80-0595 | MAR 82 |
| 658 | F-16A | USAF | 61-317 | 80-0596 | MAR 82 |
| 659 | F-16A | USAF | 61-318 | 80-0597 | APR 82 |
| 660 | F-16A | BAF | 6H-44 | 78-0159 | APR 82 |
| 661 | F-16A | RNLAF | 6D-45 | 78-0256 | APR 82 |
| 662 | F-16A | EAF | 9E-4 | 80-0642 | APR 82 |
| 663 | F-16B | EAF | 9F-5 | 80-0648 | APR 82 |
| 664 | F-16A | USAF | 61-319 | 80-0598 | APR 82 |
| 665 | F-16A | USAF | 61-320 | 80-0599 | APR 82 |
| 666 | F-16A | USAF | 61-321 | 80-0600 | APR 82 |
| 667 | F-16A | RDAF | 6F-28 | 78-0201 | APR 82 |
| 668 | F-16A | RNLAF | 6D-46 | 78-0257 | APR 82 |
| 669 | F-16A | USAF | 61-322 | 80-0601 | APR 82 |
| 670 | F-16A | USAF | 61-323 | 80-0602 | APR 82 |
| 671 | F-16A | USAF | 61-324 | 80-0603 | APR 82 |
| 672 | F-16A | USAF | 61-325 | 80-0604 | APR 82 |
| 673 | F-16A | USAF | 61-326 | 80-0605 | APR 82 |
| 674 | F-16A | BAF | 6H-45 | 78-0160 | APR 82 |
| 675 | F-16B | RNAF | 6L-7 | 78-0307 | APR 82 |
| 676 | F-16A | USAF | 61-327 | 80-0606 | APR 82 |
| 677 | F-16A | USAF | 61-328 | 80-0607 | APR 82 |
| 678 | F-16A | USAF | 61-329 | 80-0608 | APR 82 |
| 679 | F-16A | USAF | 61-330 | 80-0609 | APR 82 |
| 680 | F-16A | USAF | 61-331 | 80-0610 | MAY 82 |
| 681 | F-16A | BAF | 6H-46 | 78-0161 | MAY 82 |
| 682 | F-16B | RNLAF | 6E-13 | 78-0271 | MAY 82 |
| 683 | F-16B | USAF | 62-80 | 80-0638 | MAY 82 |
| 684 | F-16A | EAF | 9E-5 | 80-0643 | MAY 82 |
| 685 | F-16A | USAF | 61-332 | 80-0611 | MAY 82 |
| 686 | F-16A | USAF | 61-333 | 80-0612 | MAY 82 |
| 687 | F-16A | USAF | 61-334 | 80-0613 | MAY 82 |
| 688 | F-16A | RDAF | 6F-29 | 78-0202 | MAY 82 |
| 689 | F-16A | RNLAF | 6D-47 | 78-0258 | MAY 82 |
| 690 | F-16A | USAF | 61-335 | 80-0614 | MAY 82 |
| 691 | F-16A | USAF | 61-336 | 80-0615 | MAY 82 |
| 692 | F-16A | USAF | 61-337 | 80-0616 | MAY 82 |
| 693 | F-16A | USAF | 61-338 | 80-0617 | MAY 82 |
| 694 | F-16A | USAF | 61-339 | 80-0618 | MAY 82 |
| 695 | F-16A | RDAF | 6F-30 | 78-0203 | MAY 82 |
| 696 | F-16A | RNAF | 6K-29 | 78-0300 | MAY 82 |
| 697 | F-16A | USAF | 61-340 | 80-0619 | MAY 82 |
| 698 | F-16A | USAF | 61-341 | 80-0620 | MAY 82 |
| 699 | F-16A | USAF | 61-342 | 80-0621 | MAY 82 |
| 700 | F-16A | USAF | 61-343 | 80-0622 | MAY 82 |

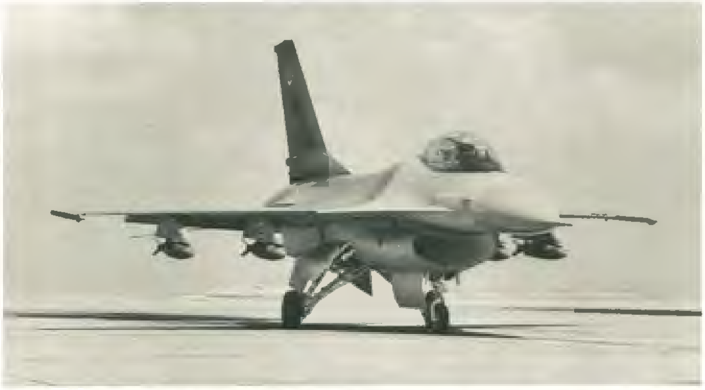
# F-16's By Wing/Fighter Group: 388th TFW



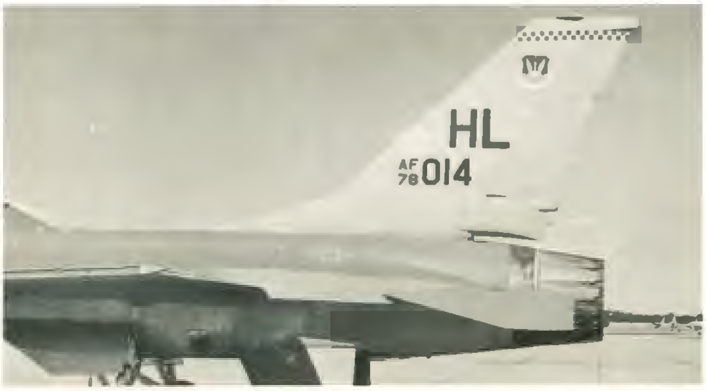
*Experimental camouflage scheme was tested by two Hill AFB F-16's including F-16B, 78-0096, of the 16th TFTS. Other airplane so painted was F-16A, 79-0008 (see color section). General Dynamics*



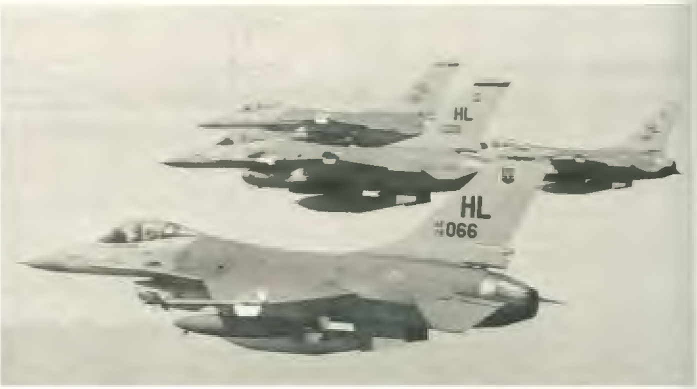
*F-16B 78-0091 of the 421st TFS as it sits on transient ramp at Offutt AFB. Note speed pack and size of one-piece canopy. George Cockle*



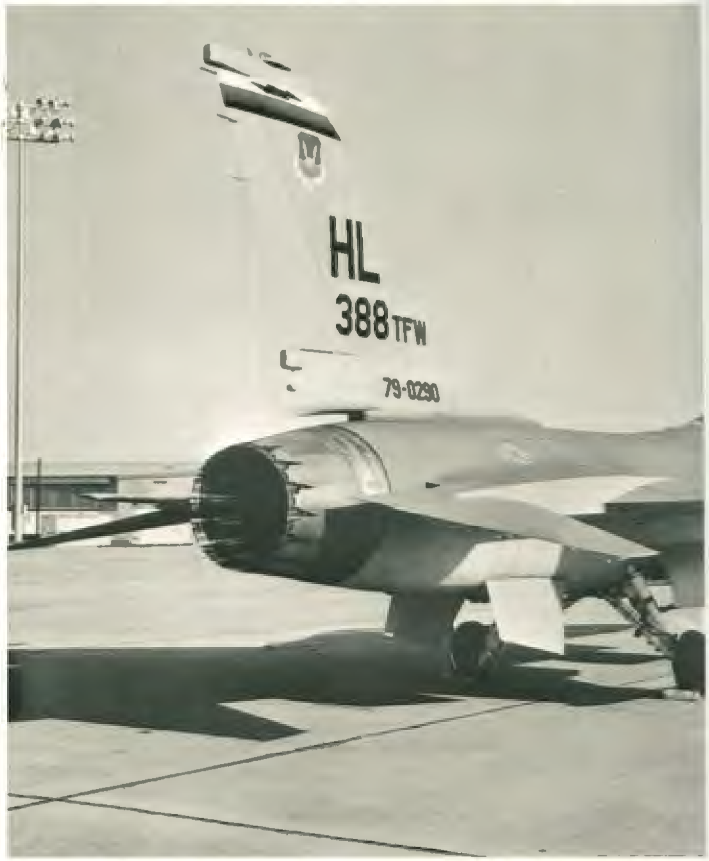
*F-16A, 79-0315, of the 421st TFS, prepares for weapons safety check at Bergstrom AFB prior to TDY training mission to bombing range at Fort Hood, Texas. Four 500 pound iron bombs are suspended from wing pylons. Aerofax*



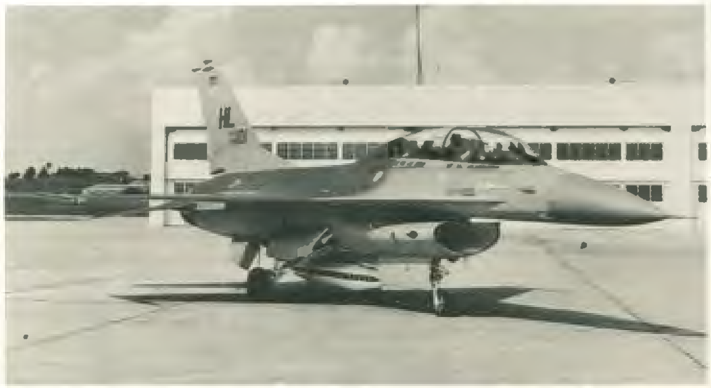
*Unusual markings show Nellis stripe at tail fin flash (57th FW) but Hill AFB (HL) tail code. This is a MOT&E aircraft. George Cockle*



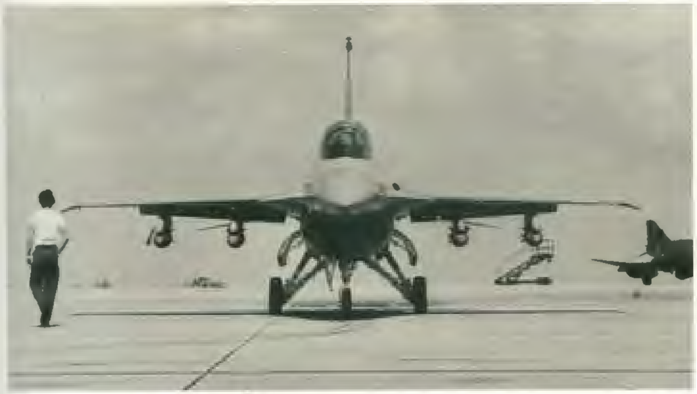
*All four 388th TFW fighter squadrons are represented here, including (starting with the most distant airplane) the 421st TFS, the 16th TFTS, the 34th TFS, and the 4th TFS. General Dynamics*



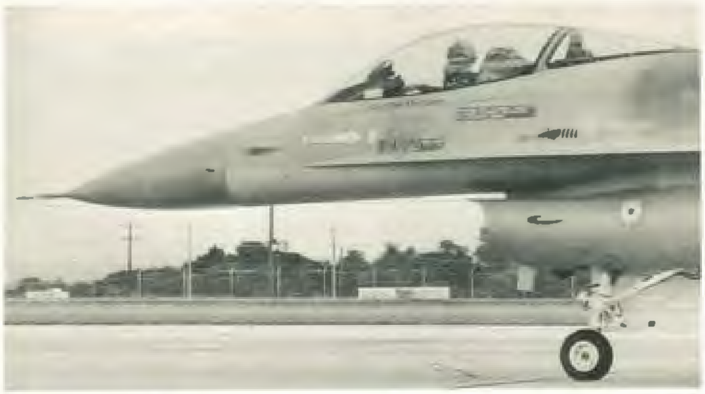
*F-16A, 79-0290, sits on ramp at Bergstrom AFB with special vertical fin markings denoting wing commander's airplane. Aerofax*



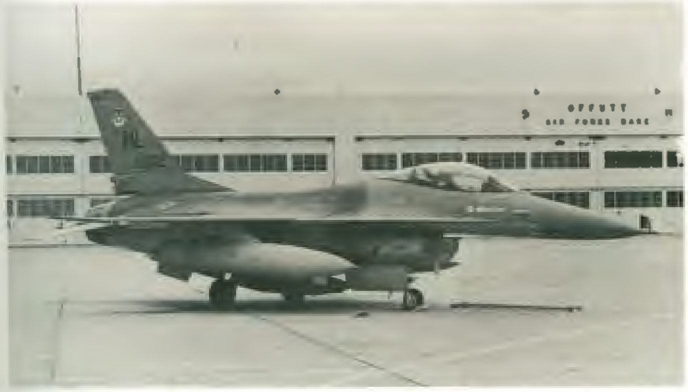
*F-16B, 78-0101, of the 4th TFS, transient at Offutt AFB George Cockle*



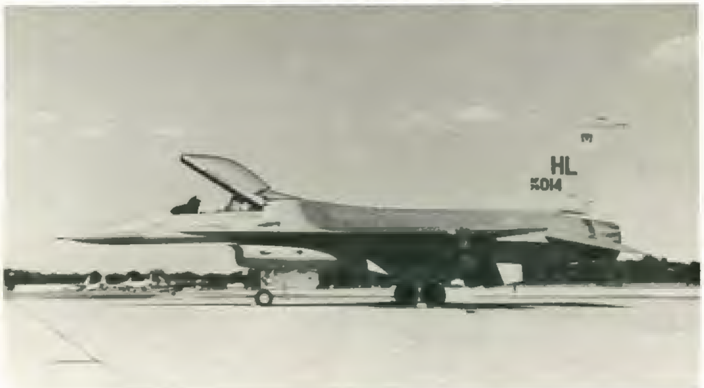
Head-on view of 421st TFS F-16A prior to weapons safety check. Aerofax



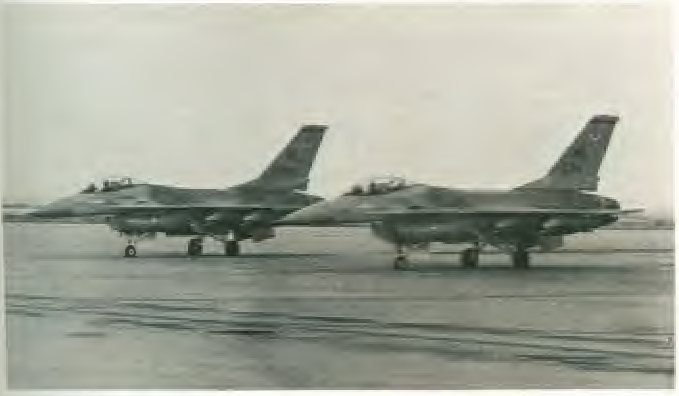
Close-up of 421st TFS F-16A nose section showing location of squadron patch just above nose gear on side of intake duct. Location of warning markings is also readily visible. Aerofax



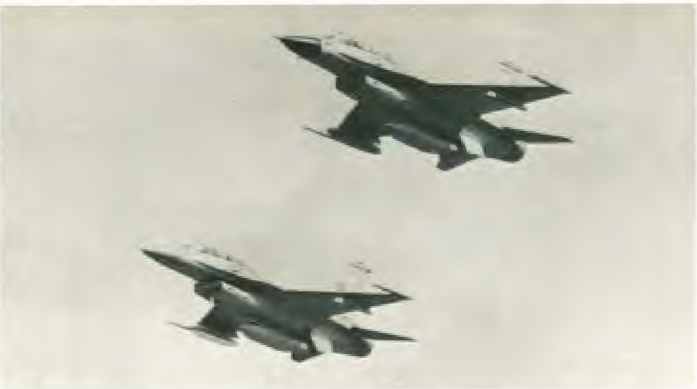
F-16A, 78-0002, with drop tanks in place, sits as transient at Offutt AFB. George Cockle



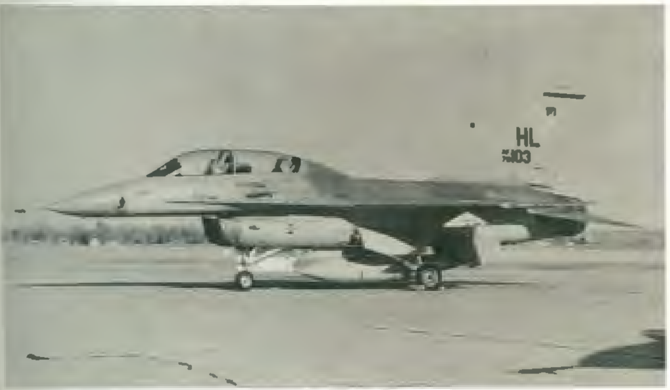
F-16A, 78-0014 of the 16th TFTS sits on ramp at Offutt AFB. George Cockle



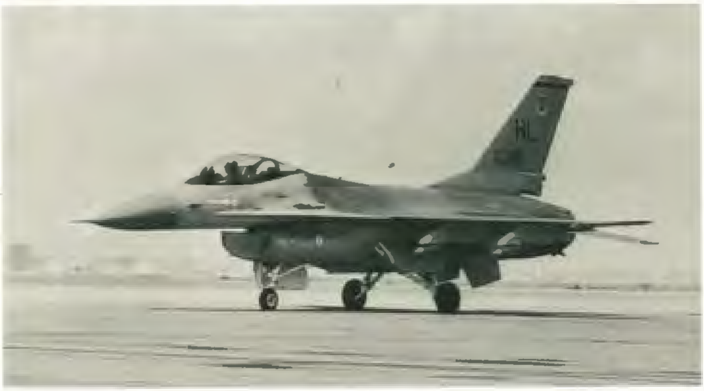
Two 421st TFS F-16A's await takeoff clearance at Bergstrom AFB during practice bombing exercise at Fort Hood, Texas. Both aircraft have four 500 pound iron bombs slung from wing pylons. Aerofax



Two 388th TFW F-16B's head skyward following refueling stop at Offutt AFB. Note that one airplane has original black nose radome and other has newer light-grey radome. George Cockle

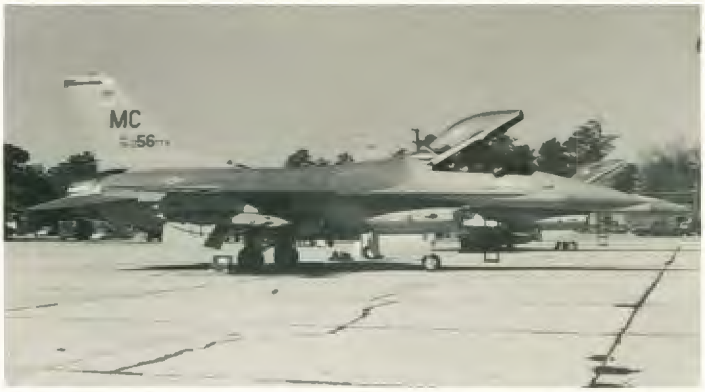


F-16B, 78-0103, of 34th TFS seen during stopover at Offutt AFB. F-16B's extended canopy transparency is readily apparent. George Cockle

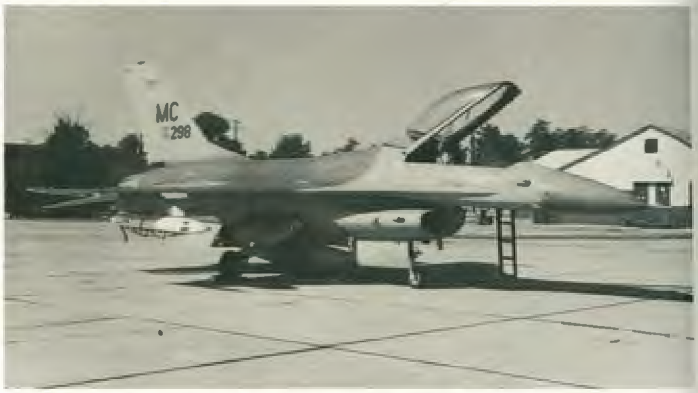


F-16A of 421st TFS awaits takeoff clearance at Bergstrom AFB. Aerofax

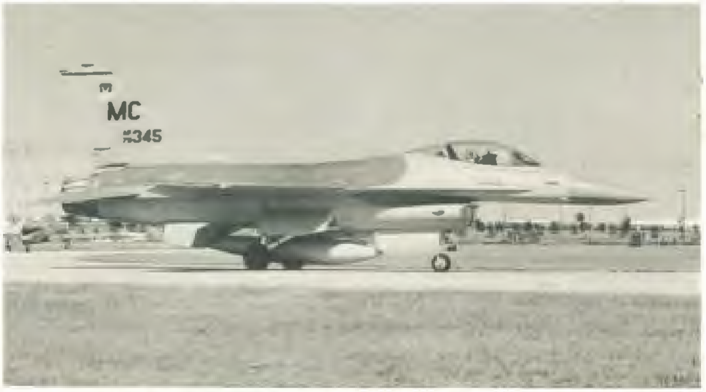
## 56th TFW



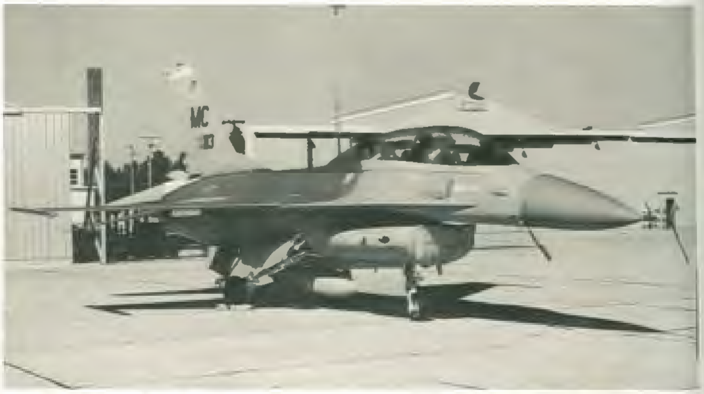
With new rocket pod suspended from outer wing pylon, 56th TFW commander's F-16A, 78-0056, sits on ramp at Shaw AFB. Norm Taylor



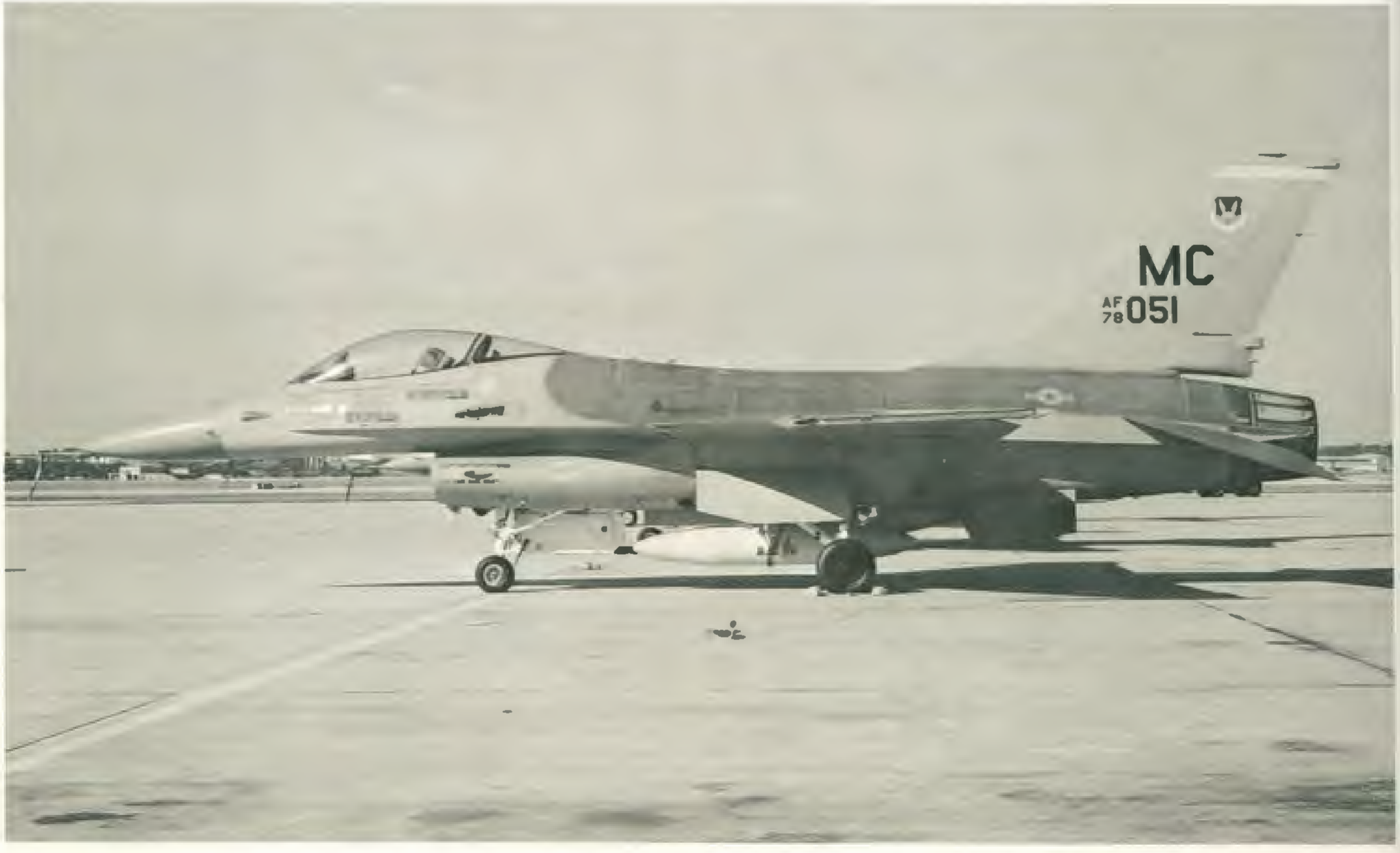
F-16A, 79-0298, of the 62nd TFTS sits on the transient ramp at Shaw AFB. Norm Taylor



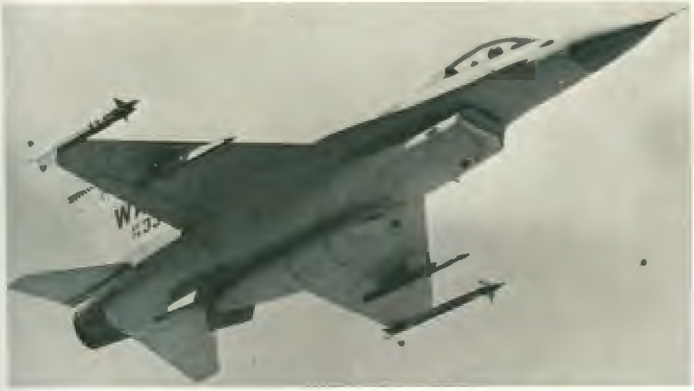
F-16A, 79-0345, of the 63rd TFTS taxies out preparatory to takeoff following fuel stop at Offutt AFB. George Cockle



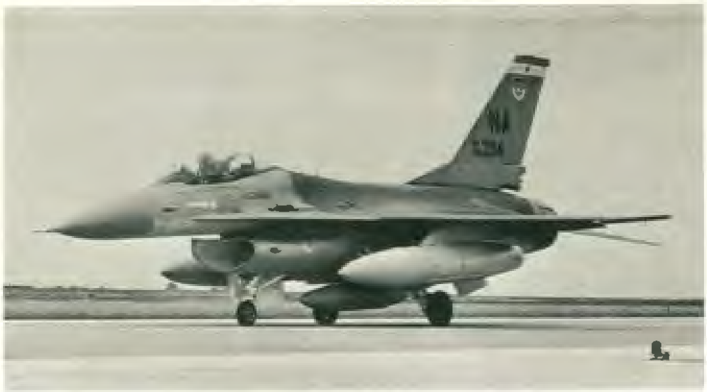
F-16B, 78-0113, of the 61st TFTS sits on transient ramp at Shaw AFB. Norm Taylor



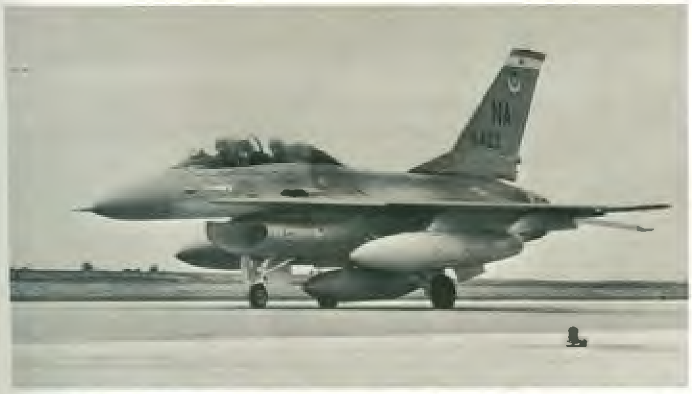
F-16A, 78-0051, of the 61st TFTS sits on transient ramp at Kelly AFB. Norm Taylor via Dr. Carl Eddy



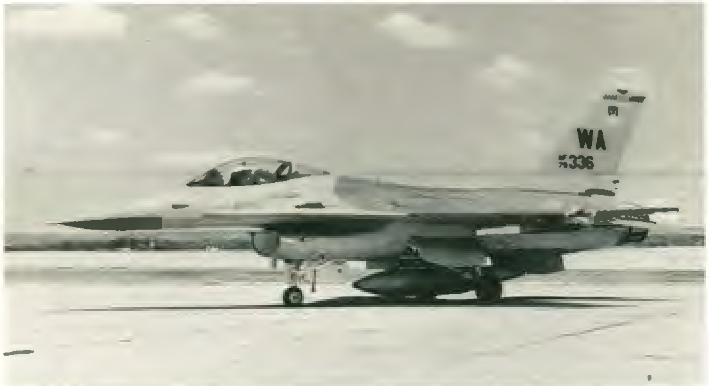
F-16A, 79-0336, from the 430th TFS, departs Offutt AFB following refueling stop. George Cockle



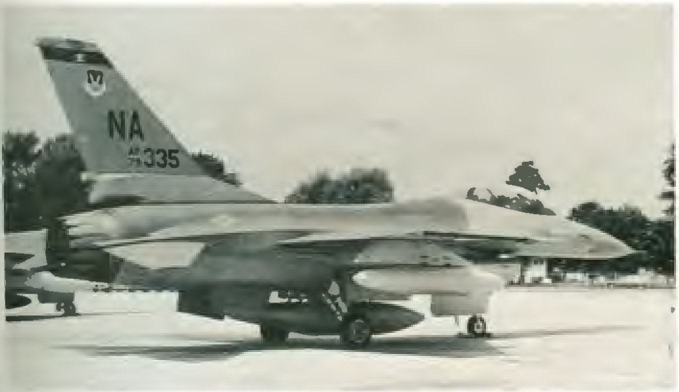
F-16A, 79-0394, of the 429th TFS, taxies following refueling stop at Bergstrom AFB. Aerofax



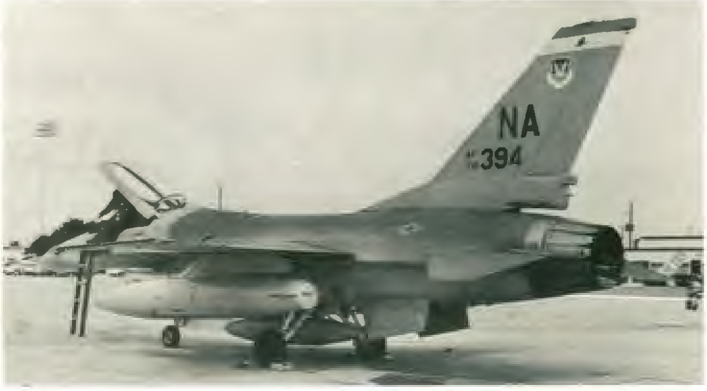
F-16B, 79-0423, of the 429th TFS, taxies following refueling stop at Bergstrom AFB. Aerofax



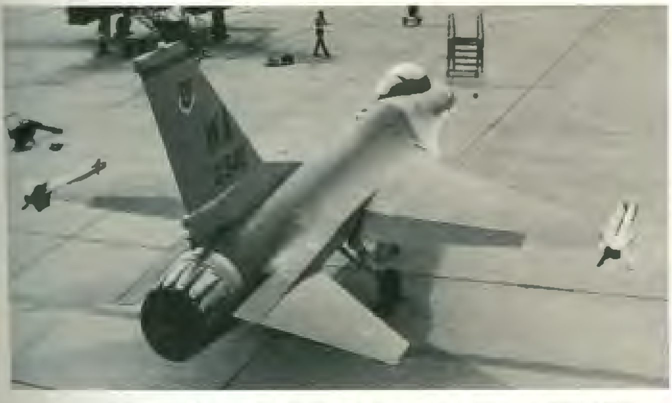
F-16A, 79-0336, of the 430th TFS, taxies out for takeoff from Offutt AFB following refueling stop. George Cockle



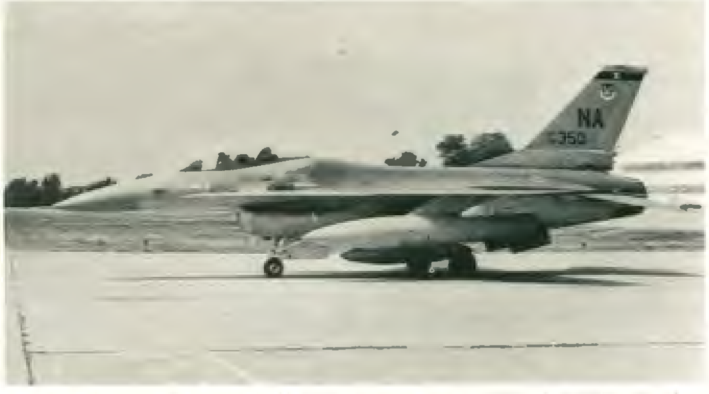
F-16A, 79-0335, of the 428th TFS, prepares for taxi at Offutt AFB following refueling stop. George Cockle



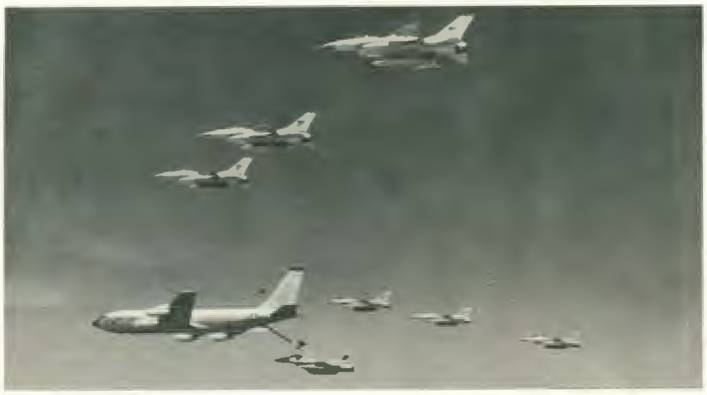
F-16A, 79-0394, of the 429th TFS, undergoes ground check by pilot prior to departure from Bergstrom AFB. Aerofax



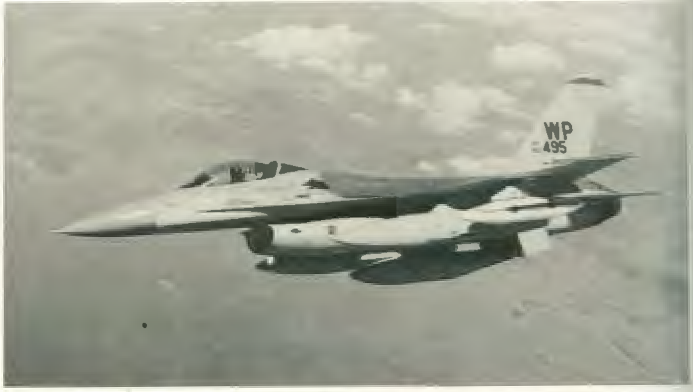
Unusual view of F-16A, 80-0540, of the 430th TFS at Hill AFB. Hal McCormack



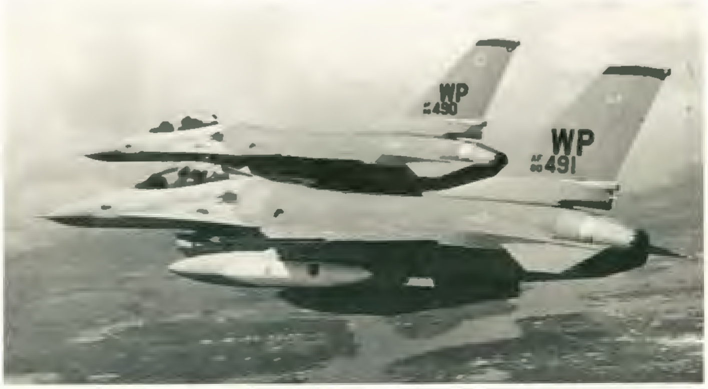
F-16A, 79-0350, of the 428th TFS, taxies out at Offutt AFB following refueling stop. George Cockle



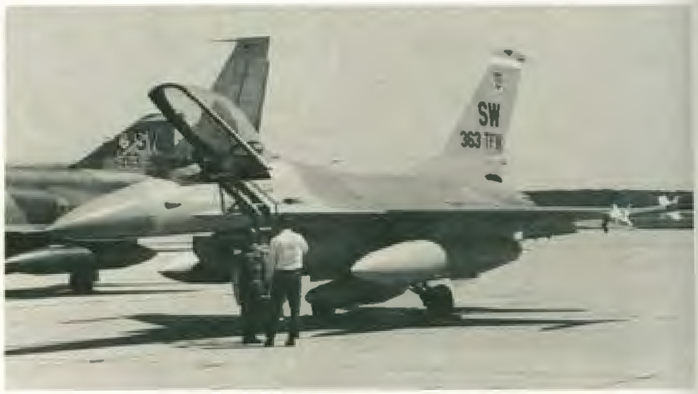
Seven F-16A's of the 35th TFS refuel from a KC-135A over the Pacific on their way to Kunsan AB in Korea. General Dynamics



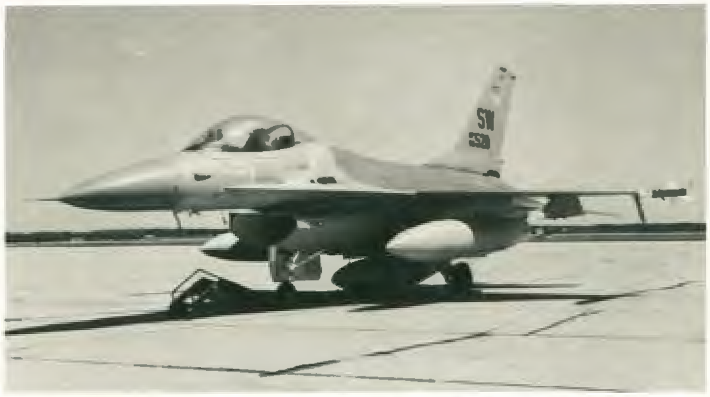
F-16A, 80-0495, of 35th TFS carries "Wolfpack" wolf head on fuselag side just under aft canopy section. General Dynamics



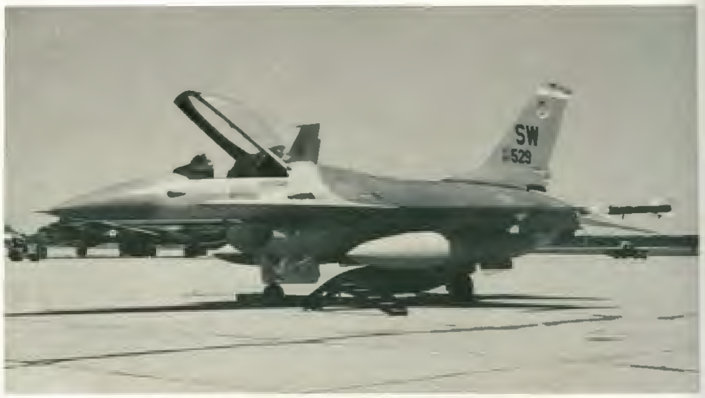
Two F-16A's, 80-0490 and 80-0491, of 35th TFS formate over Kunsan AB, Korea shortly after their arrival. General Dynamics



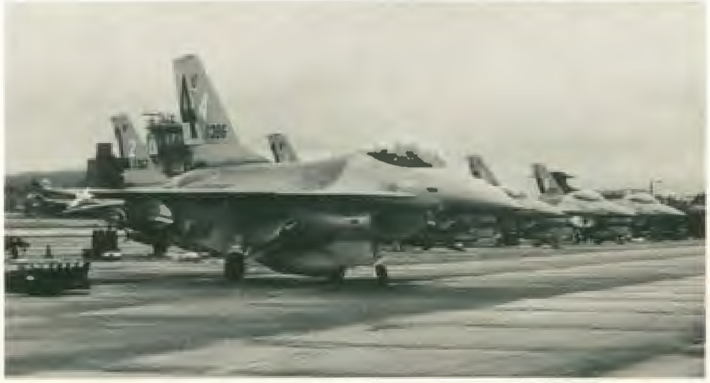
363rd TFW Commander's aircraft, F-16A, 79-0363. Norm Taylor



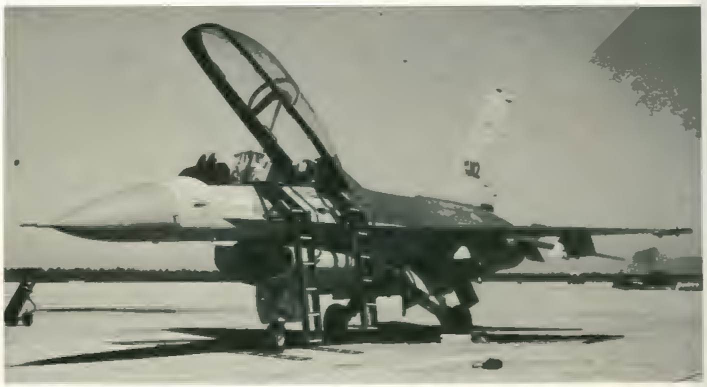
F-16A, 80-0528, of the 19th TFS, 363rd TFW, Shaw AFB. Norm Taylor



F-16A, 80-0529, of the 17th TFS, 363rd TFW, Shaw AFB. Norm Taylor



Unusual markings were applied to visiting 388th TFW F-16's during RAF bombing competition at RAF Lossiemouth. Note that each vertical fin was painted with two numbers, one adorning the rudder and the other, the vertical fin. General Dynamics



Markings applied to F-16B, 78-0112 of the 3264th Test Wing, Eglin AFB. Norm Taylor

# Selected USAF F-16 Markings

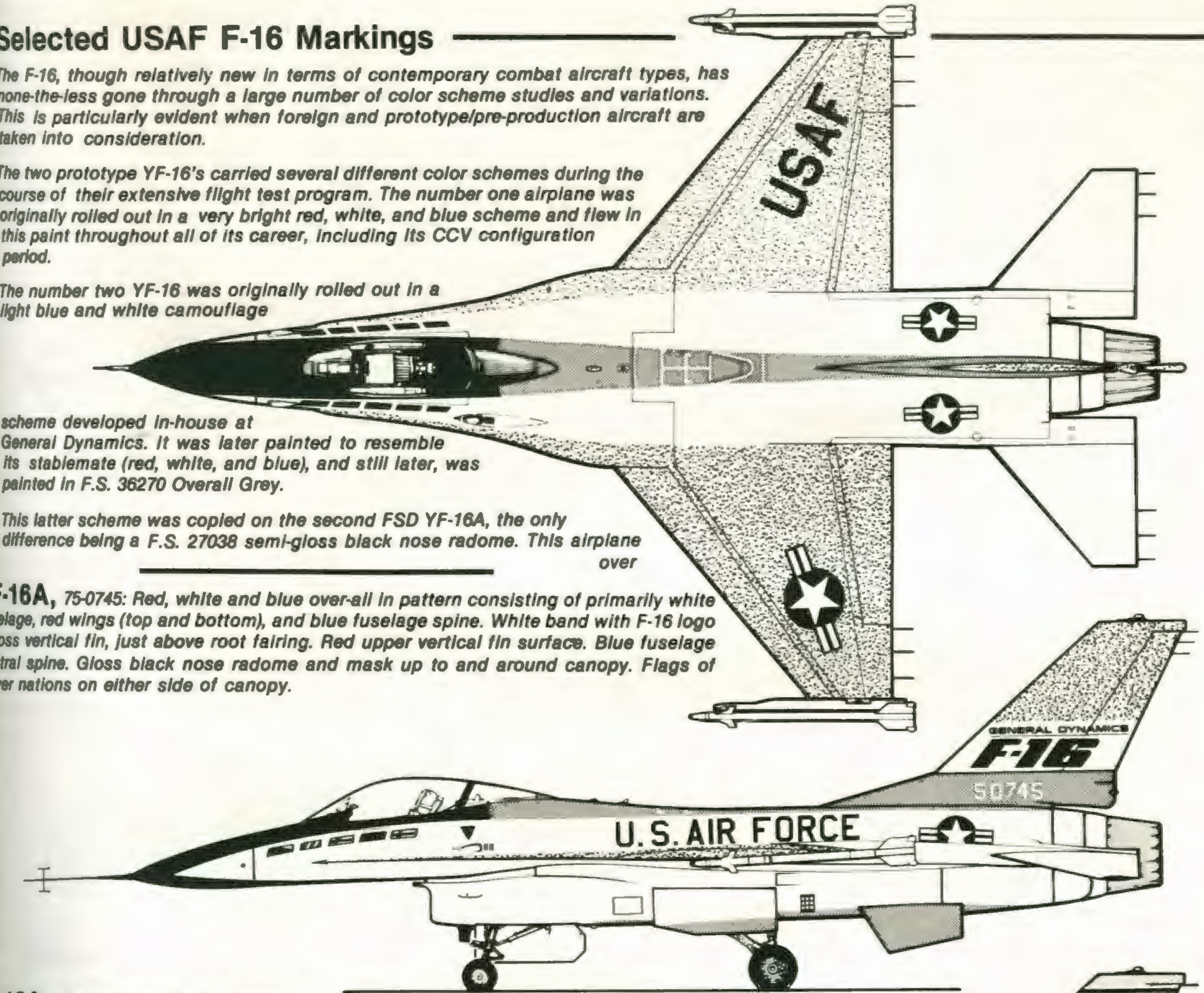
*The F-16, though relatively new in terms of contemporary combat aircraft types, has none-the-less gone through a large number of color scheme studies and variations. This is particularly evident when foreign and prototype/pre-production aircraft are taken into consideration.*

*The two prototype YF-16's carried several different color schemes during the course of their extensive flight test program. The number one airplane was originally rolled out in a very bright red, white, and blue scheme and flew in this paint throughout all of its career, including its CCV configuration period.*

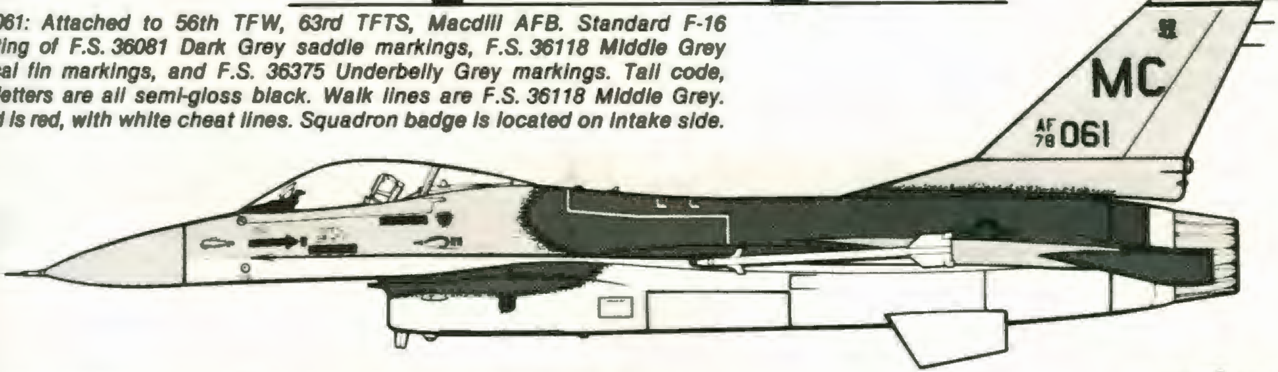
*The number two YF-16 was originally rolled out in a light blue and white camouflage scheme developed in-house at General Dynamics. It was later painted to resemble its stablemate (red, white, and blue), and still later, was painted in F.S. 36270 Overall Grey.*

*This latter scheme was copied on the second FSD YF-16A, the only difference being a F.S. 27038 semi-gloss black nose radome. This airplane over*

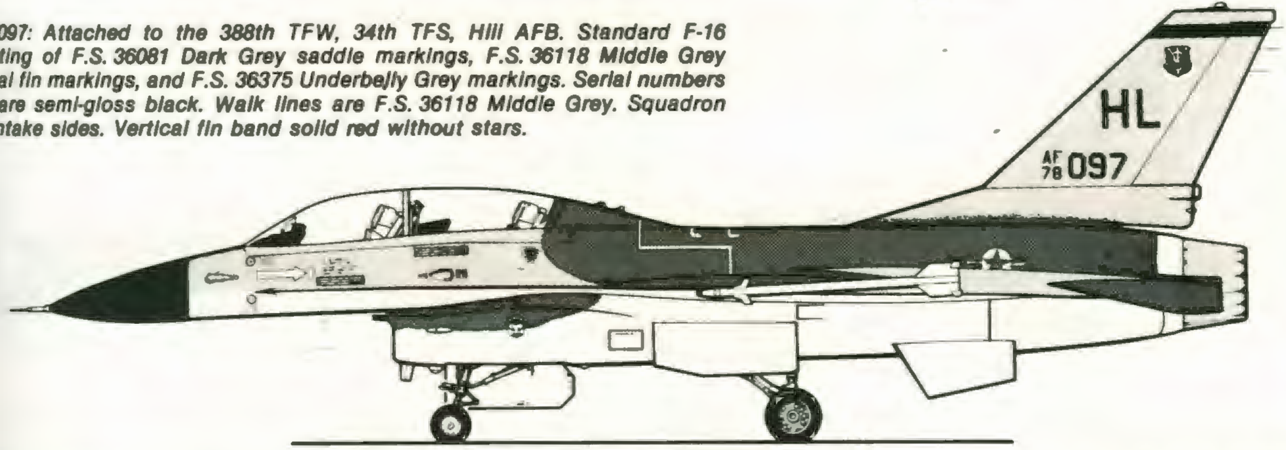
**F-16A,** *75-0745: Red, white and blue over-all in pattern consisting of primarily white selage, red wings (top and bottom), and blue fuselage spine. White band with F-16 logo cross vertical fin, just above root fairing. Red upper vertical fin surface. Blue fuselage entral spine. Gloss black nose radome and mask up to and around canopy. Flags of uyer nations on either side of canopy.*



**F-16A,** *78-0061: Attached to 56th TFW, 63rd TFTS, Macdill AFB. Standard F-16 scheme consisting of F.S. 36081 Dark Grey saddle markings, F.S. 36118 Middle Grey nose and vertical fin markings, and F.S. 36375 Underbelly Grey markings. Tail code, numerals, and letters are all semi-gloss black. Walk lines are F.S. 36118 Middle Grey. Vertical fin band is red, with white cheat lines. Squadron badge is located on intake side.*

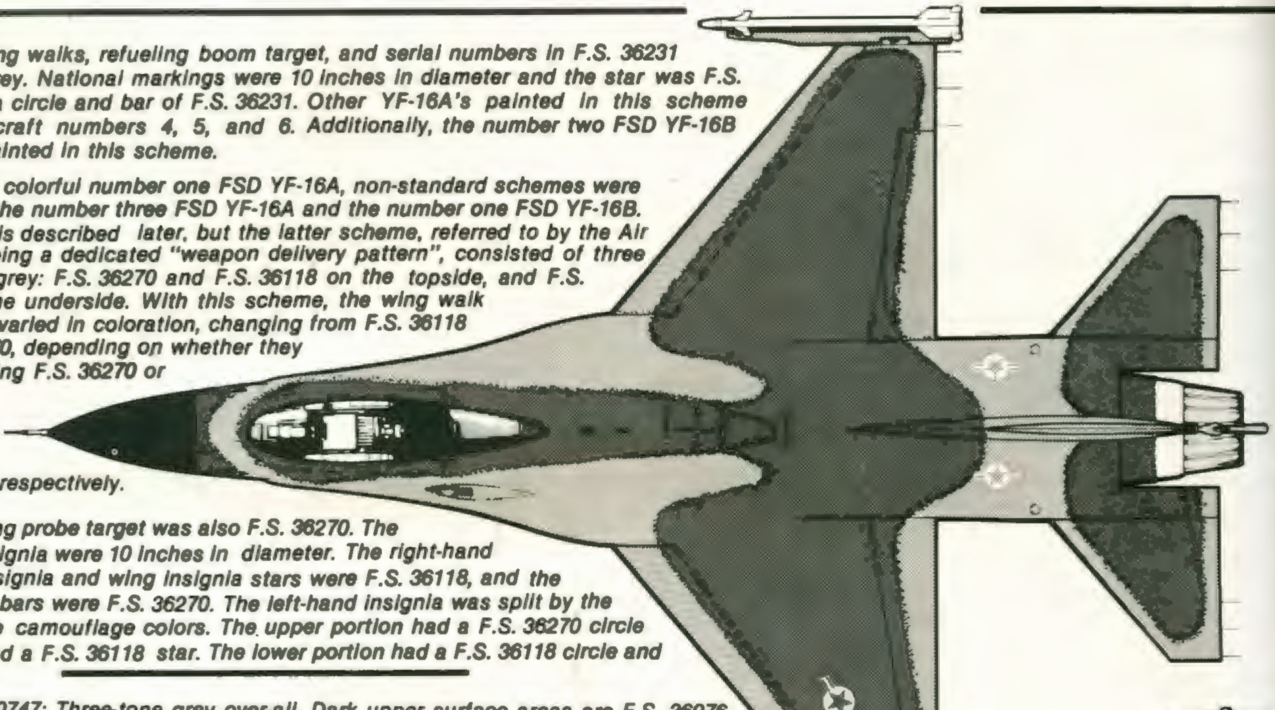


**F-16B,** *78-0097: Attached to the 388th TFW, 34th TFS, Hill AFB. Standard F-16 scheme consisting of F.S. 36081 Dark Grey saddle markings, F.S. 36118 Middle Grey nose and vertical fin markings, and F.S. 36375 Underbelly Grey markings. Serial numbers on vertical fin are semi-gloss black. Walk lines are F.S. 36118 Middle Grey. Squadron badge on the intake sides. Vertical fin band solid red without stars.*



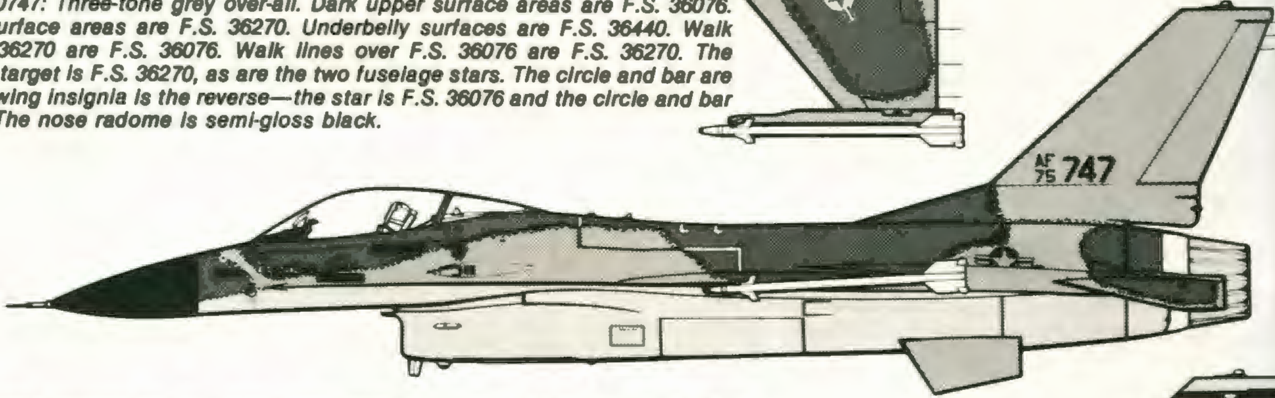
also had wing walks, refueling boom target, and serial numbers in F.S. 36231 Dark Gull Grey. National markings were 10 inches in diameter and the star was F.S. 36270 with a circle and bar of F.S. 36231. Other YF-16A's painted in this scheme include aircraft numbers 4, 5, and 6. Additionally, the number two FSD YF-16B was also painted in this scheme.

Besides the colorful number one FSD YF-16A, non-standard schemes were applied to the number three FSD YF-16A and the number one FSD YF-16B. The former is described later, but the latter scheme, referred to by the Air Force as being a dedicated "weapon delivery pattern", consisted of three shades of grey: F.S. 36270 and F.S. 36118 on the topside, and F.S. 36492 on the underside. With this scheme, the wing walk lines also varied in coloration, changing from F.S. 36118 to F.S. 36270, depending on whether they were crossing F.S. 36270 or F.S. 36118, respectively.

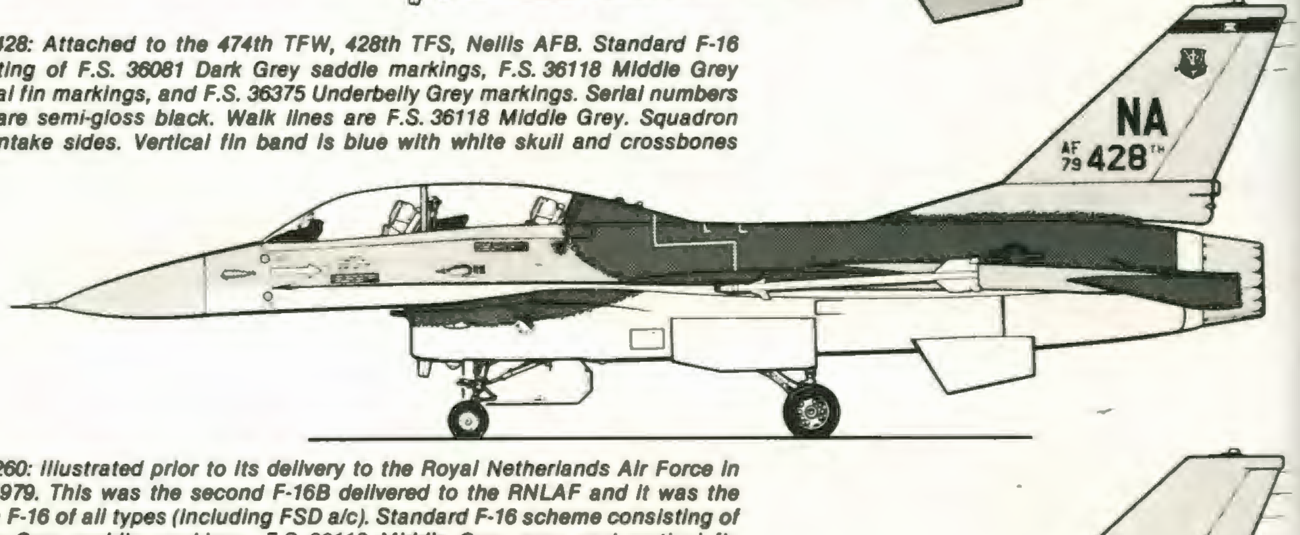


The refuelling probe target was also F.S. 36270. The national insignia were 10 inches in diameter. The right-hand fuselage insignia and wing insignia stars were F.S. 36118, and the circles and bars were F.S. 36270. The left-hand insignia was split by the two surface camouflage colors. The upper portion had a F.S. 36270 circle and bar, and a F.S. 36118 star. The lower portion had a F.S. 36118 circle and

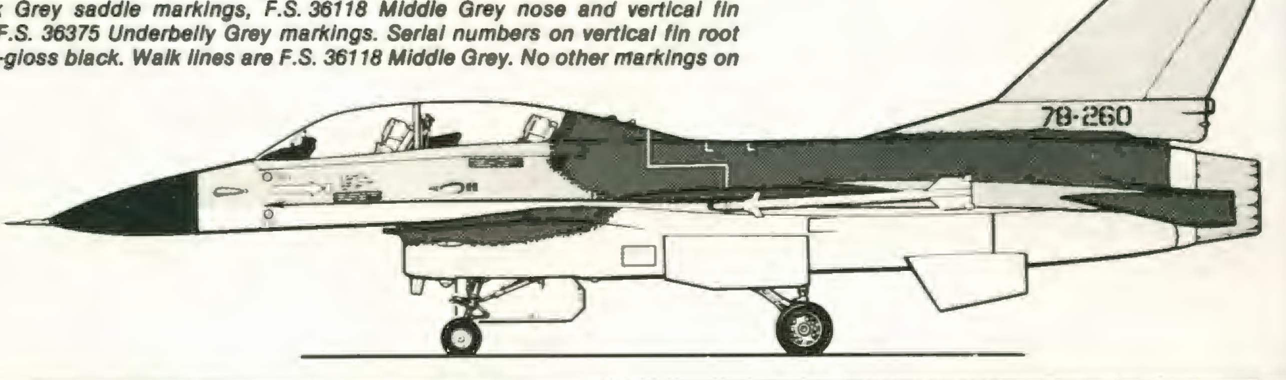
**YF-16A,** *75-0747: Three-tone grey over-all. Dark upper surface areas are F.S. 36076. Lighter upper surface areas are F.S. 36270. Underbelly surfaces are F.S. 36440. Walk lines over F.S. 36270 are F.S. 36076. Walk lines over F.S. 36076 are F.S. 36270. The refuelling probe target is F.S. 36270, as are the two fuselage stars. The circle and bar are F.S. 36076. The wing insignia is the reverse—the star is F.S. 36076 and the circle and bar are F.S. 36270. The nose radome is semi-gloss black.*



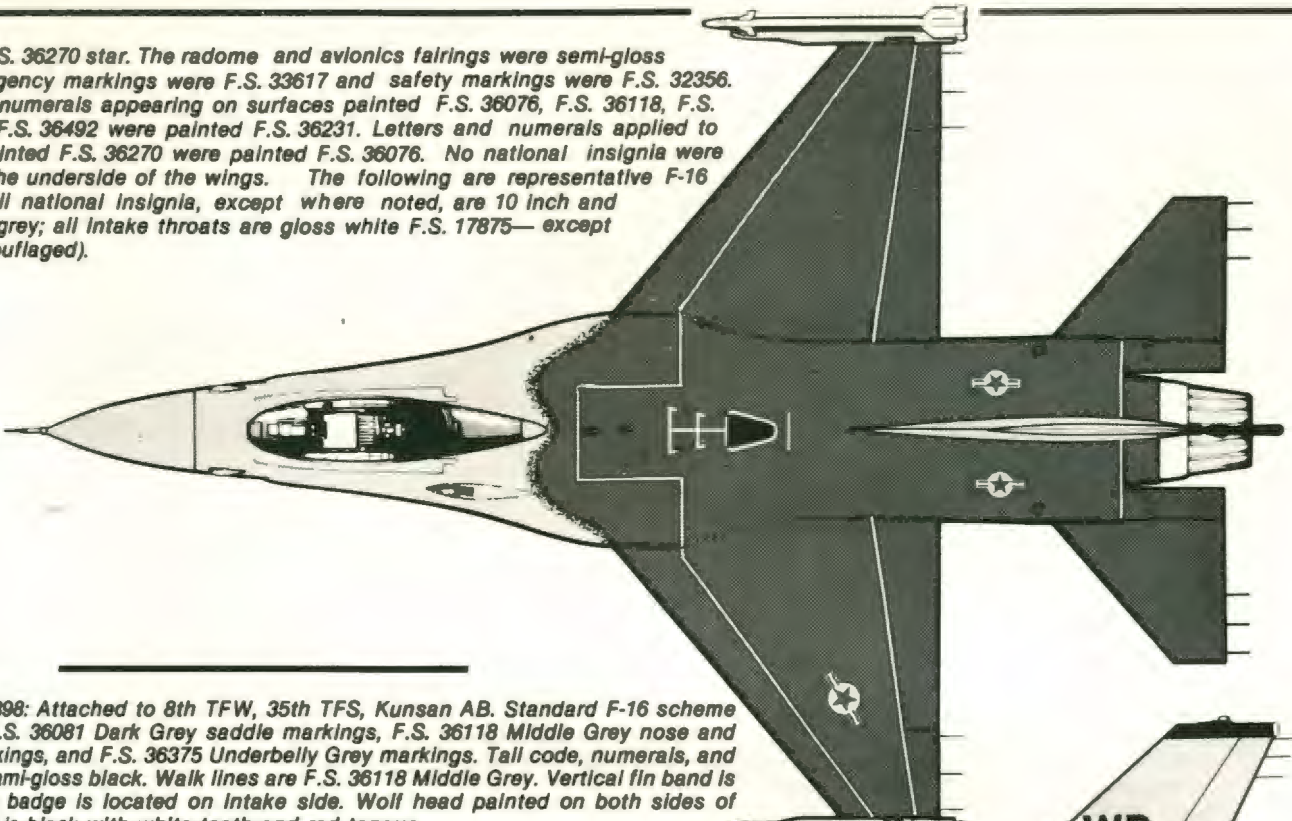
**F-16B,** *79-0428: Attached to the 474th TFW, 428th TFS, Nellis AFB. Standard F-16 scheme consisting of F.S. 36081 Dark Grey saddle markings, F.S. 36118 Middle Grey nose and vertical fin markings, and F.S. 36375 Underbelly Grey markings. Serial numbers on vertical fin are semi-gloss black. Walk lines are F.S. 36118 Middle Grey. Squadron badge on the intake sides. Vertical fin band is blue with white skull and crossbones in the center.*



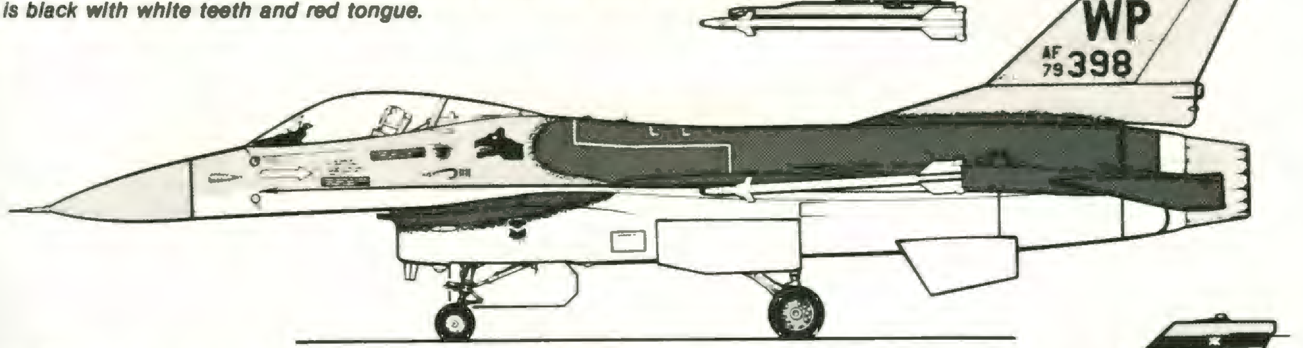
**F-16B,** *78-0260: Illustrated prior to its delivery to the Royal Netherlands Air Force in September of 1979. This was the second F-16B delivered to the RNLAF and it was the 57th production F-16 of all types (including FSD a/c). Standard F-16 scheme consisting of F.S. 36081 Dark Grey saddle markings, F.S. 36118 Middle Grey nose and vertical fin markings, and F.S. 36375 Underbelly Grey markings. Serial numbers on vertical fin root fairing are semi-gloss black. Walk lines are F.S. 36118 Middle Grey. No other markings on the airplane.*



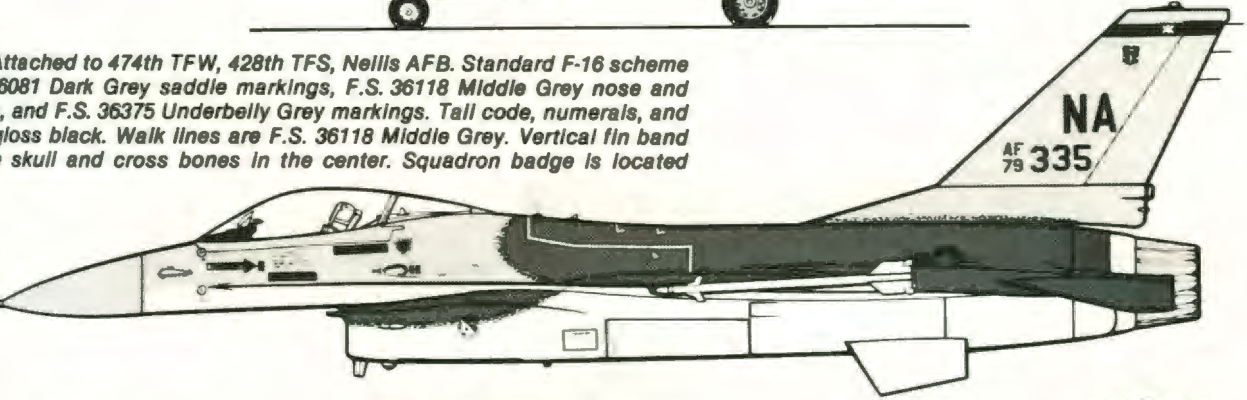
*bar, and a F.S. 36270 star. The radome and avionics fairings were semi-gloss black. Emergency markings were F.S. 33617 and safety markings were F.S. 32356. Letters and numerals appearing on surfaces painted F.S. 36076, F.S. 36118, F.S. 36440, and F.S. 36492 were painted F.S. 36231. Letters and numerals applied to surfaces painted F.S. 36270 were painted F.S. 36076. No national insignia were applied to the underside of the wings. The following are representative F-16 schemes (all national insignia, except where noted, are 10 inch and semi-gloss grey; all intake throats are gloss white F.S. 17875— except where camouflaged).*



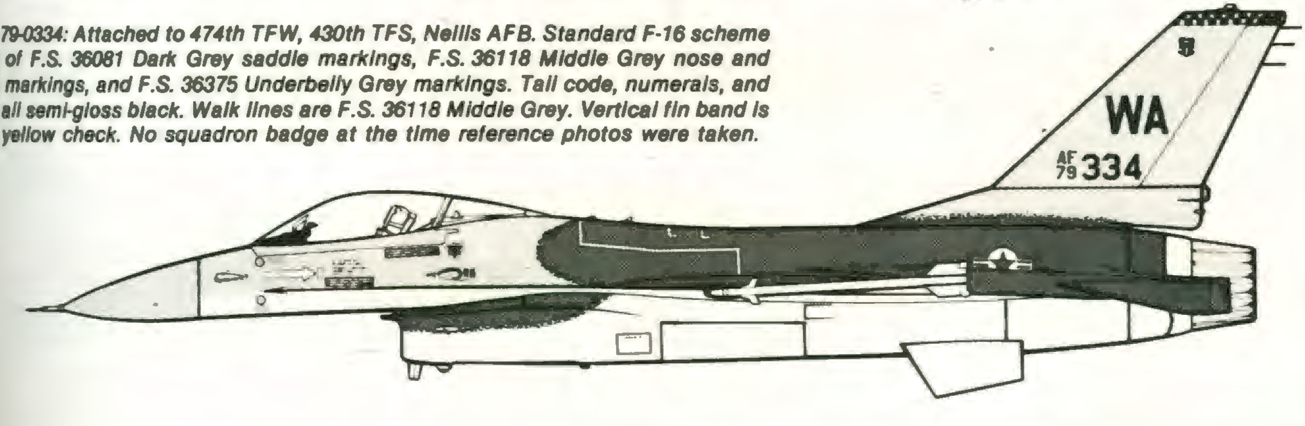
**F-16A,** *79-0398: Attached to 8th TFW, 35th TFS, Kunsan AB. Standard F-16 scheme consisting of F.S. 36081 Dark Grey saddle markings, F.S. 36118 Middle Grey nose and vertical fin markings, and F.S. 36375 Underbelly Grey markings. Tail code, numerals, and letters are all semi-gloss black. Walk lines are F.S. 36118 Middle Grey. Vertical fin band is blue. Squadron badge is located on intake side. Wolf head painted on both sides of fuselage. Head is black with white teeth and red tongue.*

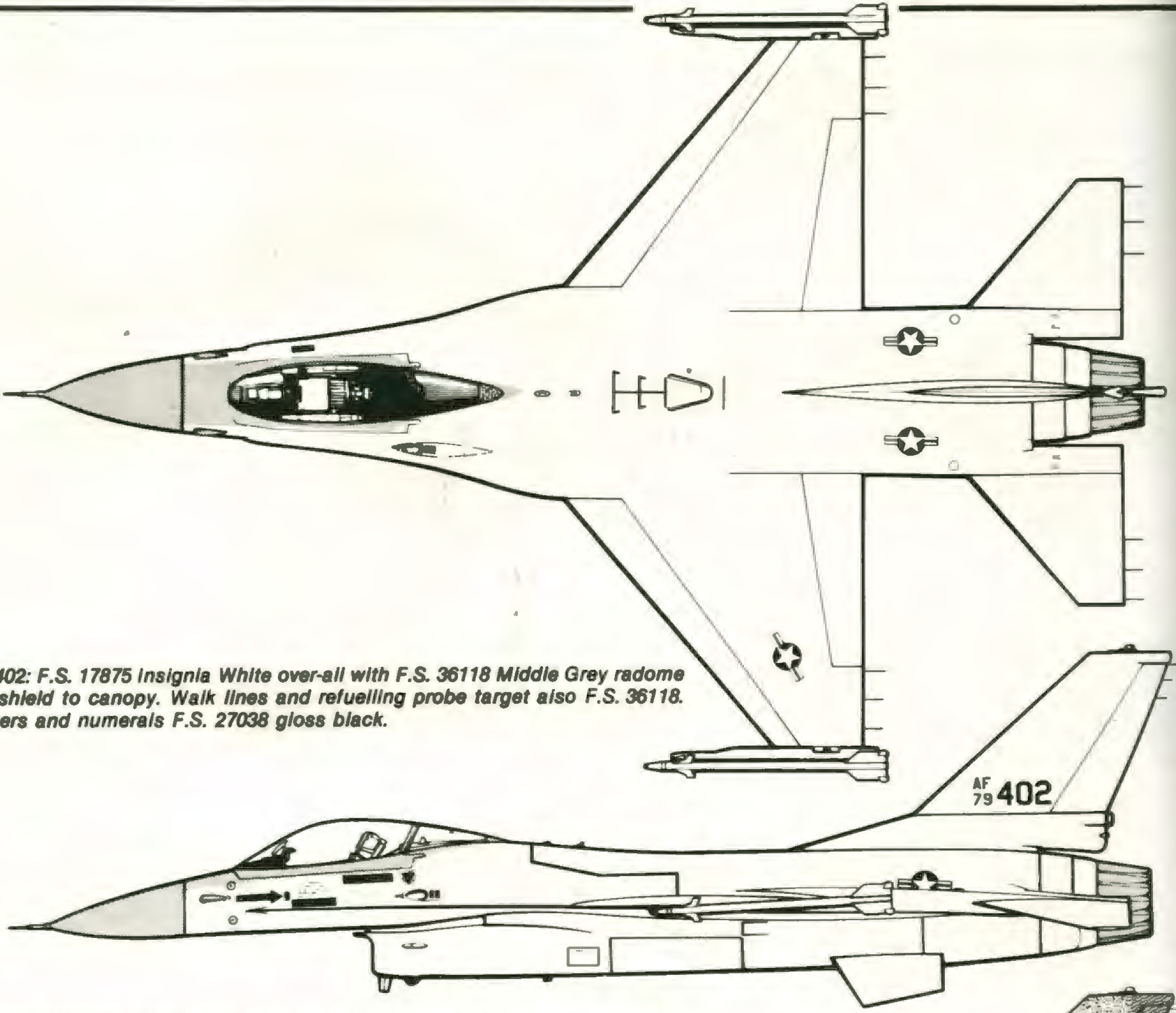


**F-16A,** *79-0335: Attached to 474th TFW, 428th TFS, Nellis AFB. Standard F-16 scheme consisting of F.S. 36081 Dark Grey saddle markings, F.S. 36118 Middle Grey nose and vertical fin markings, and F.S. 36375 Underbelly Grey markings. Tail code, numerals, and letters are all semi-gloss black. Walk lines are F.S. 36118 Middle Grey. Vertical fin band is blue with a white skull and cross bones in the center. Squadron badge is located on intake side.*



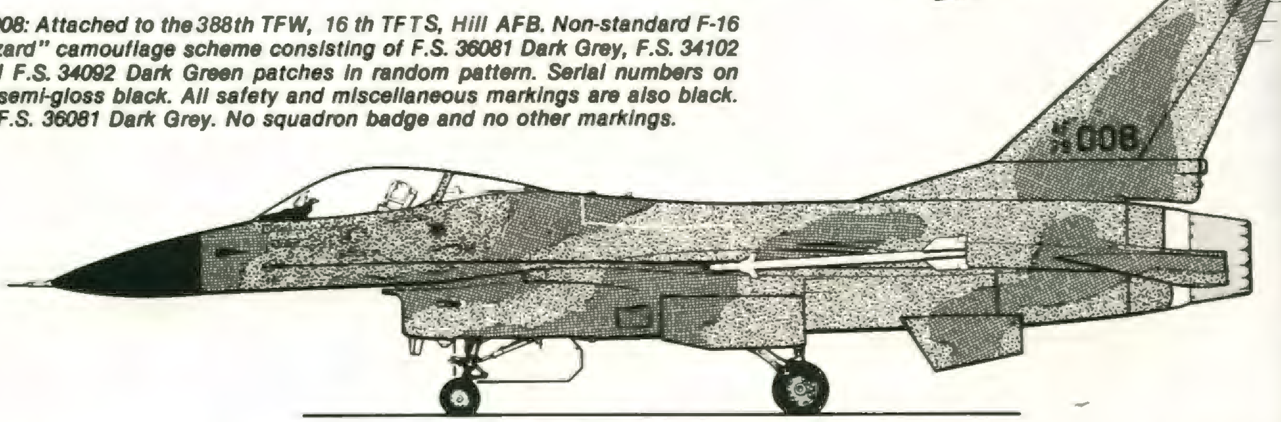
**F-16A,** *79-0334: Attached to 474th TFW, 430th TFS, Nellis AFB. Standard F-16 scheme consisting of F.S. 36081 Dark Grey saddle markings, F.S. 36118 Middle Grey nose and vertical fin markings, and F.S. 36375 Underbelly Grey markings. Tail code, numerals, and letters are all semi-gloss black. Walk lines are F.S. 36118 Middle Grey. Vertical fin band is black and yellow check. No squadron badge at the time reference photos were taken.*



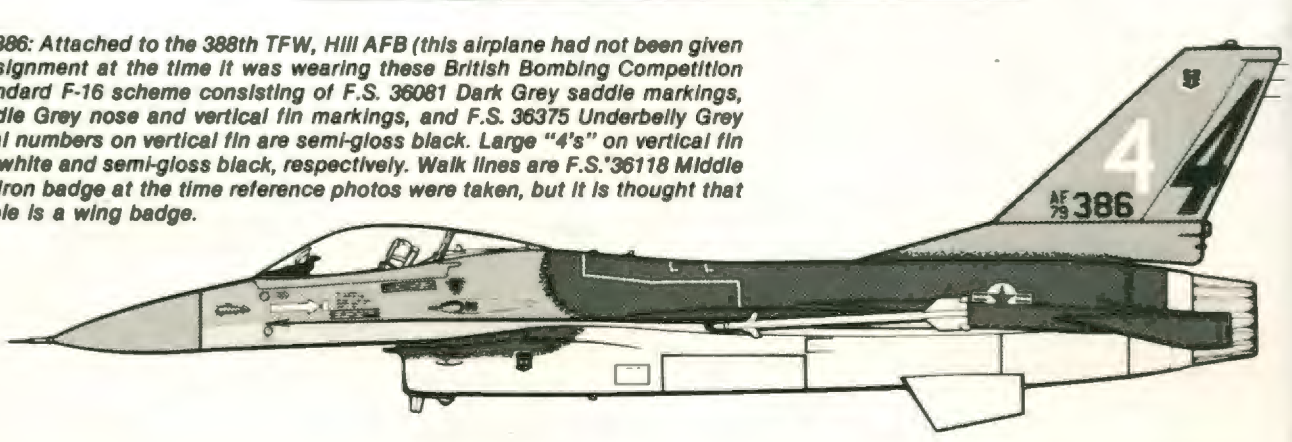


**F-16A,** *79-0402: F.S. 17875 Insignia White over-all with F.S. 36118 Middle Grey radome and anti-glare shield to canopy. Walk lines and refuelling probe target also F.S. 36118. Vertical fin letters and numerals F.S. 27038 gloss black.*

**F-16A,** *79-0008: Attached to the 388th TFW, 16 th TFTS, Hill AFB. Non-standard F-16 wraparound "lizard" camouflage scheme consisting of F.S. 36081 Dark Grey, F.S. 34102 Olive Drab, and F.S. 34092 Dark Green patches in random pattern. Serial numbers on vertical fin are semi-gloss black. All safety and miscellaneous markings are also black. Walk lines are F.S. 36081 Dark Grey. No squadron badge and no other markings.*



**F-16A,** *79-0386: Attached to the 388th TFW, Hill AFB (this airplane had not been given a squadron assignment at the time it was wearing these British Bombing Competition markings). Standard F-16 scheme consisting of F.S. 36081 Dark Grey saddle markings, F.S. 36118 Middle Grey nose and vertical fin markings, and F.S. 36375 Underbelly Grey markings. Serial numbers on vertical fin are semi-gloss black. Large "4's" on vertical fin are semi-gloss white and semi-gloss black, respectively. Walk lines are F.S. 36118 Middle Grey. No squadron badge at the time reference photos were taken, but it is thought that the badge visible is a wing badge.*



# CHAPTER 12

## NATO PROGRAMS AND FOREIGN SALES

*All four NATO alliance F-16 operators are represented by these four F-16B's. From front to rear they include Denmark, Norway, Belgium, and the Netherlands. General Dynamics*

Foreign interest in the development of the U.S. lightweight fighter can trace its origins back almost as far as the origins of the program. Indigenous lightweight fighter development throughout Europe had been undertaken on a number of occasions in the 1950's and 1960's but all, with the possible and noteworthy exception of the highly successful Dassault Mirage fighter family, had met with failure.

As mentioned in the early chapters of this book, Northrop and Lockheed, in the early 1960's, had begun to develop footholds in foreign countries around the world as a fall-out of their successful foreign sales campaigns. Lockheed had successfully marketed the F-104, and Northrop, with U.S. government backing, had sold a sizable number of F-5's.

Both aircraft types were, to all intents and purposes, lightweight fighters. They were physically small, they were relatively easy to maintain (this being particularly true for the F-5), they were maneuverable, and best of all, they were relatively inexpensive.

Unfortunately, with the possible exception of maneuverability, few, if any of these characteristics held any appeal for the U.S. military services. It was not until the advent of the "Lightweight Fighter Mafia" that a philosophical change of heart took place.

With Lockheed and Northrop showing strong interest in lightweight fighter design and, in fact, making numerous presentations to potential foreign customers, the concept and philosophy of the "Mafia" approach began to pervade foreign thinking as well—which, in fact, had settled on the lightweight fighter philosophy many years earlier.

Additionally, members of the North Atlantic Treaty Organization had agreed, in principal, to continue cooperative arrangements wherein similar aircraft types would be operated by participating agencies. The advantages to this were, on the surface at least, apparent, as significant savings could be realized not only from an economic standpoint, but from a tactical standpoint as well.

As advantageous as a multi-national (as it came to be known) fighter program appeared to be, such an undertaking was not easily executed. Among the many problems to be considered were philosophies of doing business; methods of auditing and cost accounting; procedures for tracking progress; industrial input efficiency; factors used to measure cost escalation and inflation; stability of currencies; and simple communications and social barriers.

Many of these challenges had been met and overcome by Lockheed during the course of their highly successful F-104 program, and thus precedent had been set for the new multinational fighter program when it came time to begin the F-104 replacement program selection process. The latter proved a lengthy and complex undertaking. Not only was there a wide variety of options available (besides U.S. companies vying for the contract, there were also a number of European companies, and at least one other major cooperative effort—the MRCA—Multi Role Combat Aircraft), there was also the usual problem of reaching agreement on requirements and mission capabilities.

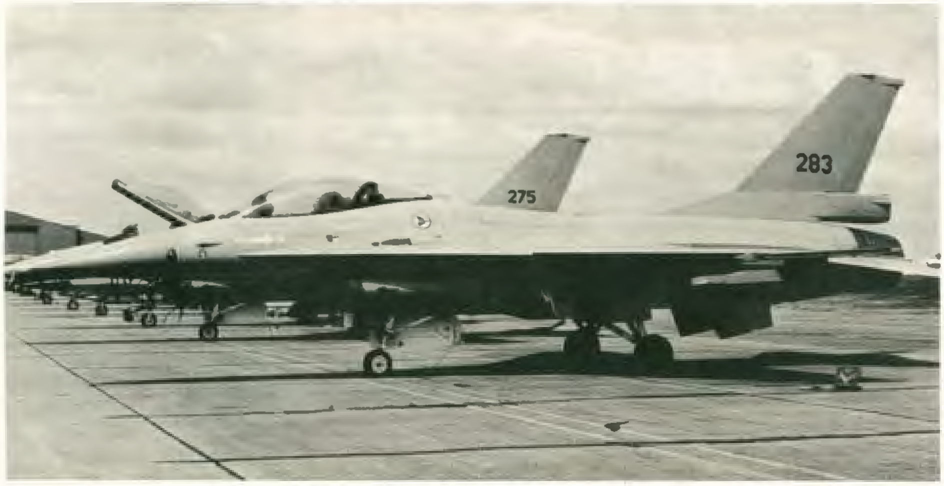
While the various NATO countries attempted to settle their differences and make a preliminary decision on whether or not to support an indegenous program or once again turn to the U.S. for help, teams of NATO representatives visited the DoD and the various manufacturers and began to develop a strong feel for their various options. These visits, of course, spurred U.S. activity as it was obvious that if the NATO elected to go with a U.S. product, it would be best to have something tangible to offer.

Lockheed and Northrop, of course, had been well aware of NATO's intentions for a long time. Accordingly, they had courted the NATO alliance with significant fervor and had taken their design studies to the point of full-scale mock-up development (the CL-1200 and P-530, respectively). On more than a few occasions it appeared that one alliance member or another was ready to sign a contract. It was assumed by both companies that if one country could be talked into a production program, the rest would follow suit.

While the various companies jockeyed for positional advantage in dealing with the NATO, the Department of Defense, and particularly the Air Force, found itself being maneuvered rather roughly into the position of having to accept the lightweight fighter as evolved from the philosophies of the "Lightweight Fighter Mafia". In the spring of 1974, the competition between the Northrop YF-17 and the General Dynamics YF-16 got underway, and in May, a NATO consortium (Belgium, Denmark, Holland, and Norway) arrived at the Pentagon to discuss possible acquisition of the winning design.

NATO, of course, looked at the lightweight fighter program in a slightly different light than the Air Force. They were farsighted enough to appreciate the program's philosophical attributes, even though at this stage of the game it was still a paper exercise. The small size, minimal complexity, and spectacular performance of the proposed lightweight fighter made it ideal for the NATO force structure.

*Virtually continuous operation in snow and ice conditions caused Norway to request that its F-16's be equipped with a drag chute for assistance during landing roll-out. F-16B, 301, is shown just after touchdown at the moment of main chute deployment. General Dynamics*



*Norwegian A.F. F-16A, 283, showing good detail of drag chute housing. Compartment remains open and uncovered. Rolf Flinzner*

NATO's plan, as unveiled during the consortium visit to the Pentagon, was for approximately 350 airplanes to be ordered—with the important understanding being that (a) acquisition costs would be off-set by major assembly production in the NATO countries, and (b) the NATO alliance would be allowed to participate in the lightweight fighter program source selection process. It was expected that European co-producers would furnish 10% of the USAF aircraft value, 40% of their own aircraft value, and 15% of the procurement value of aircraft sold to "third" countries.

Importantly, NATO was aware of the fact that a significant savings could be realized over indigenous development of a multi-national fighter because with the advent of the lightweight fighter program and its funding by the U.S. Government, development and prototyping costs could be more easily amortized.

An important consideration by the four consortium countries was the total economic package being offered by each competitor. The General Dynamics team, for instance, was told by one country that they would not necessarily choose the best performing aircraft or the one with the lowest cost, but rather the one that provided the best economic package.

Following selection of the General Dynamics F-16 as the Air Combat Fighter for the Air Force in early 1975, NATO asked for several delays before committing itself to this same airplane. Because of Northrop's well-established foothold and its early entry into the NATO market, strong support had been generated within the confines of NATO calling for the acquisition of the Northrop airplane. This, coupled with a (statistically unfounded) belief in twin-engine designs, caused the original December 1974 decision date to be delayed no less than six months.

Finally, on June 7, 1975, a joint announcement by the four NATO countries affected (Belgium, Denmark, the Netherlands, and Norway), confirmed the decision to select the F-16 over the F-17. The initial order called for 348 aircraft in total, with 116 for Belgium, 58 for Denmark, 102 for the Netherlands, and 72 for Norway. Of this number, 290 were to be single seat aircraft and 58 were to be two seat.

In 1975, when the Air Force contracted with General Dynamics for the F-16, an incentive fee was set centered around a design-to-cost recurring unit flyaway price of $4.55 million in then-year dollars. When the four European nations joined the program, a not-to-exceed price of $6.091 million was established for their aircraft. The difference in cost was due primarily to U.S. Government insistence that some of the Air Force full-scale development work be recouped; and to the fact that production of European-built F-16's takes longer than U.S.-built aircraft; and to the fact that some tooling is duplicated throughout the European production consortium.

The Memorandum of Understanding signed by the U.S. and the four European governments specified that the U.S. Department of Defense would utilize depot level maintenance and overhaul facilities established and funded by the European participating countries, as well as industry maintenance facilities in those countries. The document also required the U.S. to provide logistic support under the U.S. cooperative logistics program, and technical support as long as the F-16's remained in operational use.

The European air forces planned to start taking delivery of their F-16's in early 1979, and deliveries of the 348 aircraft ordered were to continue through 1985. Later requirements for the replacement of other aircraft were expected to generate orders for as many as 250 to 300 more F-16's.

Following contract signing and the initiation of the NATO program, General Dynamics, under contractual agreements, furnished initial support to the European co-producers in the form of:

(1) One disassembled F-16 each to Fokker and Fairey/SABCA.

(2) Six aft and center fuselages and six vertical fins to Fairey, and three of each to Fokker.

(3) Thirty ship sets of details and assemblies, including center fuselages, main landing gear doors, main landing gear build-up, wing leading edge flaps, wing trailing edge panels and flaperons, three ship sets of center fuselage components, and other assembly details to Fairey.

(4) Fifteen ship sets of aft fuselages and other assembly details to Fairey.

(5) Two ship sets of wing box structure and other details to SABCA.

(6) Six ship sets of vertical fin details to Udsen.

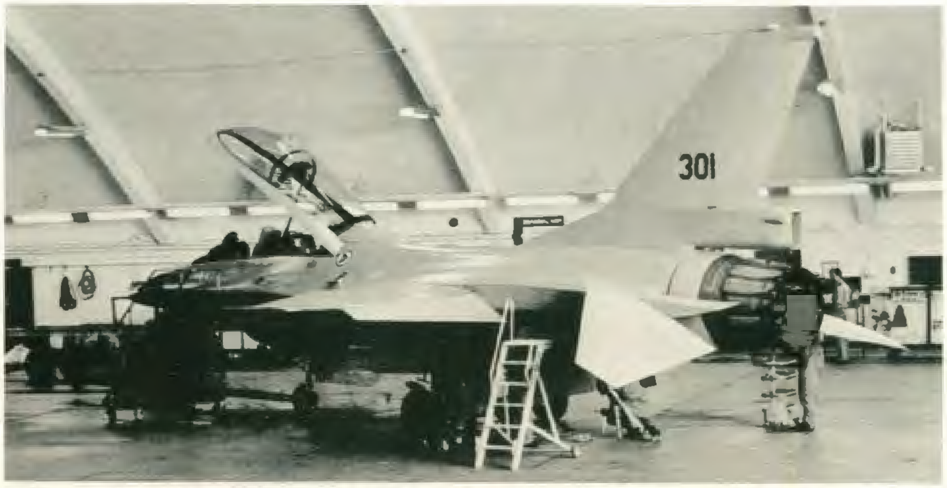
(7) Five ship sets of vertical fin details to Fairey.

Deliveries of F-16's from the primary European production centers in Belgium (SONACA and SABCA, near Gosselies—which opened their production line in February of 1978) and the Netherlands (Fokker, near Amsterdam—which opened its production line in April of 1978) began on January 26, 1979, with the first aircraft going to the Belgian Air Force (*Force Aerie'nne Belge*) from the SABCA/SONACA final assembly line. As of the date of this publication, the Belgian Air Force has a total of 116 F-16's on order and by June of 1981 had received 39 (29 F-16A's and 10 F-16B's).

The first of the four Belgian Air Force squadrons to inventory the F-16 was the 349e *escadrille*. In mid-1981, this unit became the first F-16 unit to complete NATO qualification trials and to be declared operational by the NATO.

The Royal Netherlands Air Force (Dutch *Koninklijke Luchtmacht*) was the second NATO member to receive the F-16, with the first airplane being delivered on June 6, 1979. Dutch orders currently total at 213 but an additional number are expected to be required before production is terminated. The first operational Dutch F-16's have entered service with the 322nd Squadron at Leeuwarden and the 323rd is in the process of transitioning as airplanes become available. Additional squadrons, the 311th, 312th, and 306th are forming at Volkel (the 306th squadron is a reconnaissance unit and will be equipped with podded Oldelft Orpheus day/night recce systems once the first recce-system-wired F-16 {the 59th Dutch Air Force airplane} becomes available in February of 1983).

The first Danish and Norwegian airplanes were delivered in January of 1980. The former has ordered 58 and the latter 72. The Danish airplanes are equipping the Royal Danish Air



*Norwegian F-16B, 301, undergoes routine maintenance. Chute housing also serves as mounting point for tail warning sensors. This housing will become a standard item on many of the forthcoming MSIP equipped aircraft. General Dynamics*

*Norwegian F-16A, 274, gets a good chute following landing. Large size of drag chute is readily apparent. General Dynamics*

*Netherlands A.F. F-16A bearing 306 sq. badge at Volkel AB. Note Orpheus recce pod on centerline mount. Mat Herben*

Force's (*Kongelige Danske Flyvevabnet's*) *Eskadrilles* 727 and 730 at Skrydstrup with the first deliveries to the former taking place on January 28th. This unit has now been declared operational and the 730 is expected to follow suit soon.

The Royal Norwegian Air Force (*Kongelige Norske Luftforsvaret*) has 72 F-16's on order (60 F-16A's and 12 F-16B's) and the first of these, an F-16B, was delivered to the 332nd Skv (an F-16 Operational Conversion Unit) at Rygge on January 25, 1980. The first operational unit was Skv 331 at BØdo and two other units, Skv 334 (also at BØdo) and Skv 338 at Orland, are expected to follow as aircraft became available. It is interesting to note that these latter two units are to be utilized in the anti-shipping and strike roles and as such, will be armed with *Harpoon* (at this time, only the *Maverick* is specified for the mission) air-to-surface missile.

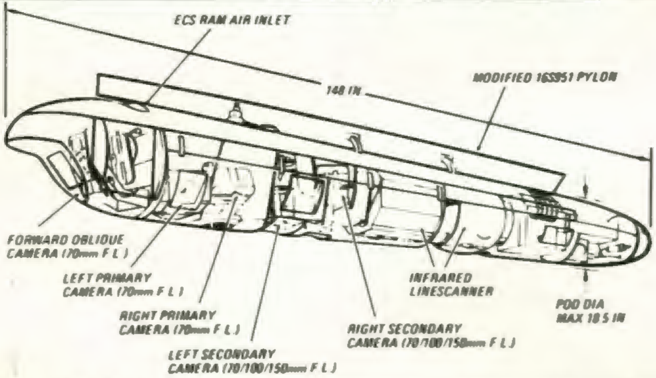
The aircraft built under the NATO consortium agreement have several relatively minor, but none-the-less noteworthy changes from their Air Force counterparts. These include the following:

(1) Norwegian aircraft are equipped with a special 23-foot diameter continuous ribbon type parachute with a switch-activated, hydromechanical deployment system. This permits operation in the snow and ice so very prevalent in Norway. The modification is quite noticeable as the drag chute container extends the fin fairing below the rudder farther aft than that of conventional F-16's.

(2) Some Dutch aircraft are to be equipped with the Netherlands-developed Orpheus Reconnaissance Pod which is a low/medium, day/night capability system with internal ECS and internal sensor controls for image motion compensation, camera cycling rate, and infrared linescanner film rate. This system, which is pod mounted on the centerline pylon, was authorized in November of 1979 and flight tested in March and April of 1980. First production deliveries, as mentioned earlier, are scheduled for February of 1983.

(3) Belgian aircraft are soon to have incorporated the Belgian-developed Loral Rapport III Internal Electronic Countermeasures System (Rapport is an acronym for rapid alert programed power management of radar targets). This unit is digitally programmable with radar warning and automatic source management. It provides electronic jamming and chaff and/or flare dispensing. It also maintains a parametric threat data file and prioritizes the threat and the countermeasure technique. Additionally, it is field reprogrammable for rapid threat change response. Plans as of mid-1981 called for installation of the system in the 56th Belgian aircraft in 1983. Belgian F-16's of the 10th Wing at Kleine Brogel will be delivered with the

*Netherlands F-16A, J-218, cruises over Dutch countryside. Netherlands has confirmed orders for 142 F-16's. General Dynamics*



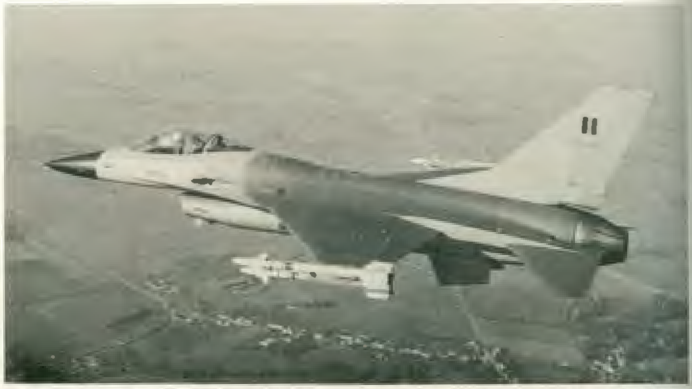
ECS RAM AIR INLET
148 IN
MODIFIED 165951 PYLON
FORWARD OBLIQUE CAMERA (70mm F L )
LEFT PRIMARY CAMERA (70mm F L )
RIGHT PRIMARY CAMERA (70mm F L )
LEFT SECONDARY CAMERA (70/100/150mm F L )
RIGHT SECONDARY CAMERA (70/100/150mm F L )
INFRARED LINESCANNER
POD DIA MAX 18 5 IN

*Details of the Netherlands-developed Orpheus Reconnaissance Pod which can be carried on the centerline pylon. General Dynamics*

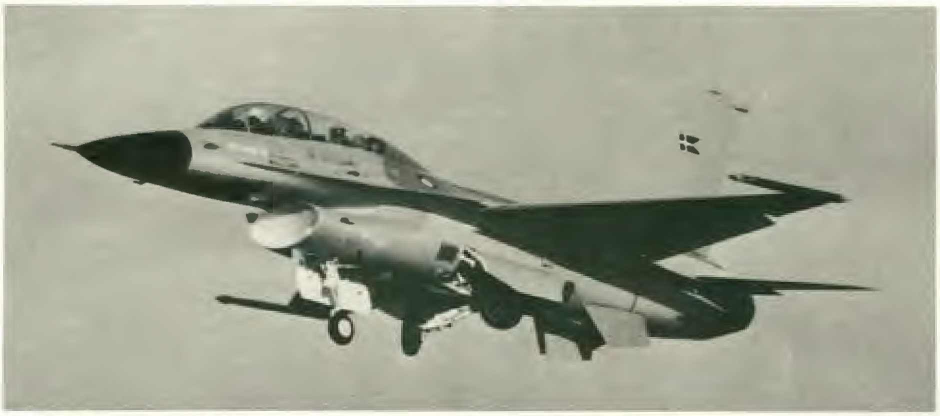
*Netherlands F-16B, J-259, hovers in ground effect just prior to touch down. Extended flap and airbrakes are easily seen. General Dynamics*

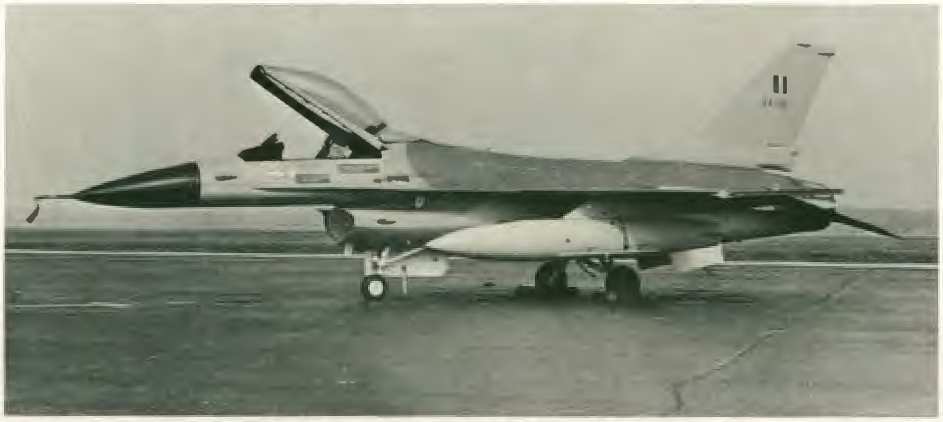
*Netherlands A.F. F-16A, J-222, taxiing out from Leeuwarden AB, mounts two 2.75" rocket pods on wing pylons. Rolf Flinzner*

*Three Danish F-16A's formate over the coast of Denmark. Note that one aircraft has original black radome. General Dynamics*


*Belgian A.F. F-16A, FA-14, demonstrates ability to carry four Sidewinders on wing tip and outer wing pylon mounts. General Dynamics*

*At high altitude, four Belgian F-16A's cruise on training sortie. Three aircraft have original black radomes and one has light grey. General Dynamics*


*Danish F-16B heads skyward on training flight as landing gear are rapidly retracted. Mains fold forward and nose gear retracts rearward. General Dynamics*


*Belgian F-16A, FA-03, during transient stop at Wright-Patterson AFB. For long range mission, airplane is equipped with two 370 gallon external wing tanks. Dave Menard via Norm Taylor*

system installed. The 1st Wing at Beauvechain will have its aircraft retrofitted with the unit. Of the total Belgian order for 116 F-16's, 20 reserved for training roles will not be equipped with the Rapport III system.

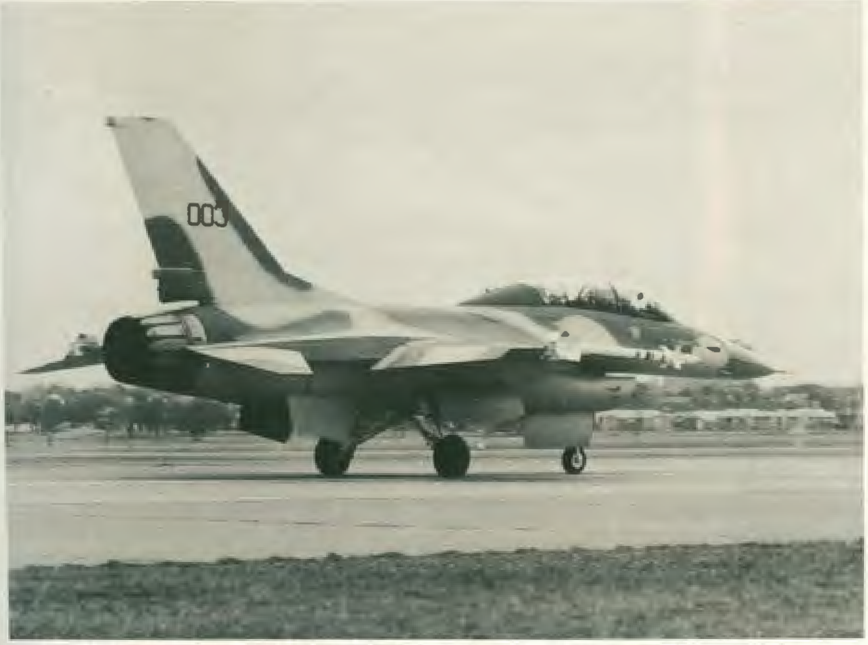
(4) Other changes which were in the original NATO requirement include a manually operated identification spot-light in the aft cockpit of Danish aircraft, a radar altimeter, and some changes in onboard avionics (a modified autopilot was also specified but this was later dropped due to economy and commonality problems).

Because of the F-16's combined price and performance package, the airplane was of course attractive to more countries than just those in Europe. The first to express strong interest in the type (outside the NATO alliance) were the Iranians who started their buy with an order for 160 aircraft. This would later be cancelled, but other mideastern countries would soon follow suit.

Among the most important of these were Israel and Egypt. The former began its buy in August of 1977, with an order for 75 aircraft (67 F-16A's and 8 F-16B's) for the Israeli Air Force (*Heyl Ha'Avir*). The first of these (F-16B, 78-0355) was turned over during official ceremonies at General Dynamics on January 31, 1980, and was delivered, along with three other aircraft, by ferry flight (11 hours and 6,000 miles) from Pease AFB to Israel. Deliveries to Israel have now been completed and there is interest being expressed in an additional order for an unknown quantity.

Israeli F-16's became the first aircraft of their type to be used in actual combat when, on June 7, 1981, eight aircraft were used to destroy the Osirak nuclear reactor near Baghdad, Iraq. With McDonnell Douglas F-15's flying top cover, the eight F-16's flew from Israel's Etzion air base in the Sinai desert to the target and back, a total distance of over 1,200 miles, without inflight refueling. Each airplane carried two 2,000 pound iron bombs and two 370 gallon wing tanks during the hi-lo-hi profile mission. Interestingly, upon their return, the eight F-16's were made mission ready within an hour as it was expected that the Iraqi's would immediately mount a retaliatory attack.

On January 15, 1982, the first Egyptian Air Force F-16 was turned over (F-16A, 80-0539—the 595th F-16 to be completed; it was flown for the first time on January 9, 1982) to Egyptian Air Force officials during ceremonies at General Dynamics Fort Worth facility. The present EAF order stands at 40 aircraft (34 F-16A's and 6 F-16B's), but this is expected to be increased by an additional 100 to 150 within the next three to five years. Additional orders will likely comprise improved Multinational Staged Improvement Program aircraft.



*Israeli Air Force F-16B, 003, taxies out for delivery flight takeoff. Israeli aircraft have distinctive desert camouflage. General Dynamics*

*Another view of Israeli Air Force F-16B, 003, during pre-delivery flight trials. Airplane was allocated USAF serial number 78-0355. General Dynamics*

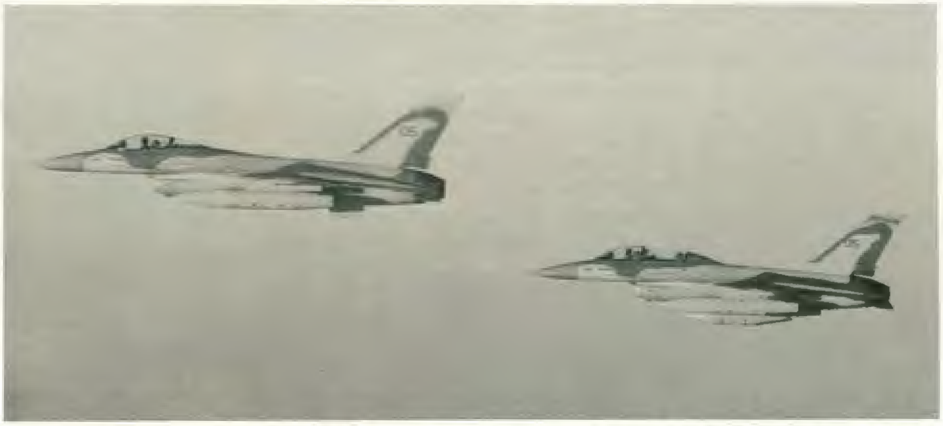
Total cost of the EAF F-16 program is $975-million including spares, support, training, and other peripherals. The first aircraft are expected to be delivered to Egypt by ferry flight in March of 1982. There they will form the 1st Regiment at An Shas Fighter AB, just northeast of Cairo. Presently, 4 Air Force F-16's (held over from Exercise Bright Star) are temporarily stationed in Egypt for introductory training work.

Other countries that have ordered the F-16 include the Republic of South Korea (36 aircraft; comprised of 30 F-16A's and 6 F-16B's, the first of which is scheduled to be delivered in February of 1986); Venezuela (24 aircraft); and Pakistan (tentative order for 40 aircraft; 6 to be delivered by December of 1982 and 34, twenty-seven months after contract signing). It is expected that these orders will be filled during the next three to five years, based on increased General Dynamics production capacity, additional orders from other sources, and prioritized Air Force needs (The Air Force, because of the large number of foreign orders, has suffered considerably in its ability to meet its own force commitments). It should also be mentioned that, as this book was going to press, Turkey had expressed a strong interest in the possibility of buying as many as 300 F-16's.

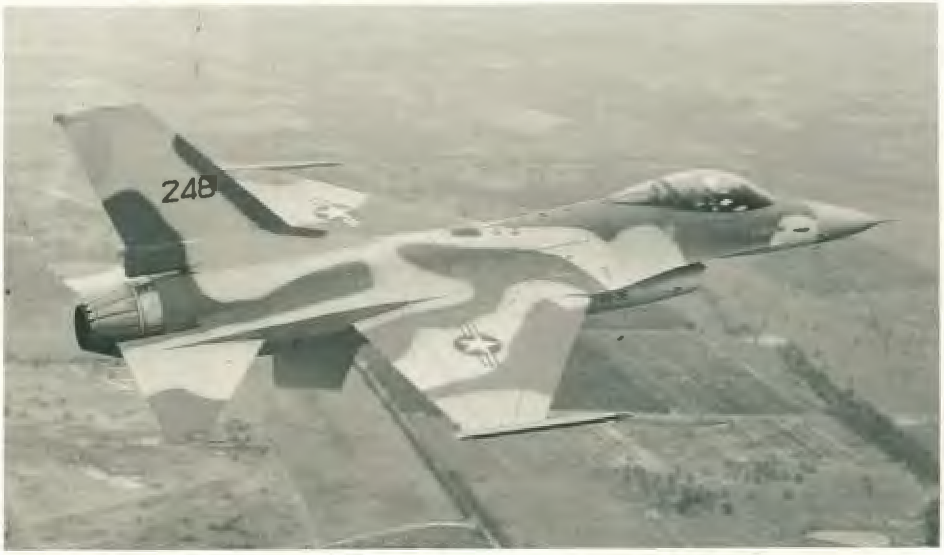
Other countries that have expressed strong interest in the airplane include Jordan, Austria, Peru, Malasia, Spain, Nigeria, Taiwan, Thailand, Greece, Australia, Singapore, and Canada (Canada and Australia have since opted for the McDonnell Douglas F-18).

The following list covers code names assigned to F-16 sales to foreign customers:

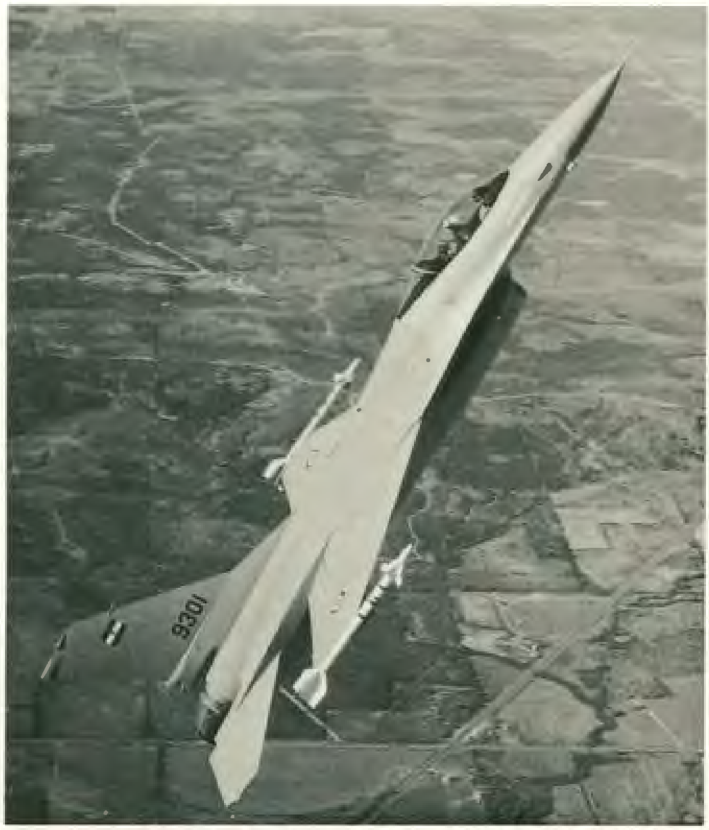
| | |
|---|---|
| Peace Marble | Israel |
| Peace Vector | Egypt |
| Peace Nova | Jordan |
| Peace Gate | Pakistan |
| Peace Delta | Venezuela |
| Peace Bridge | S. Korea |
| Peace Danube | Austria |
| Peace Zebra | Iran |
| Peace L | Peru |
| Peace B | Malasia |



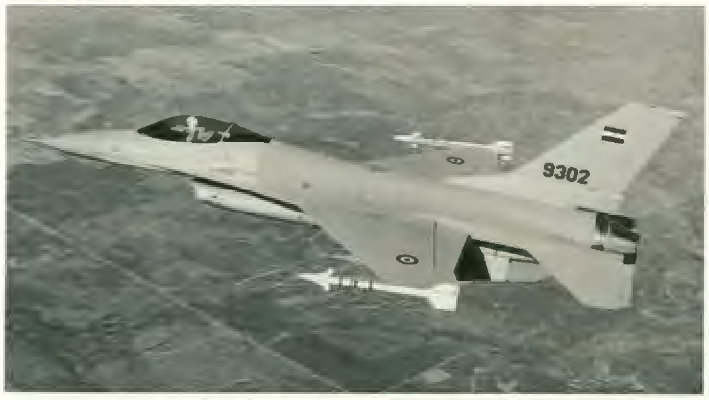
*Israeli Air Force F-16A, 105, and F-16B, 015, formate for Atlantic crossing during delivery flight. The F-16A is equipped with two 370 gallon external wing tanks and the F-16B is equipped with two 370 gallon external wing tanks and a single 300 gallon centerline drop tank. General Dynamics.*



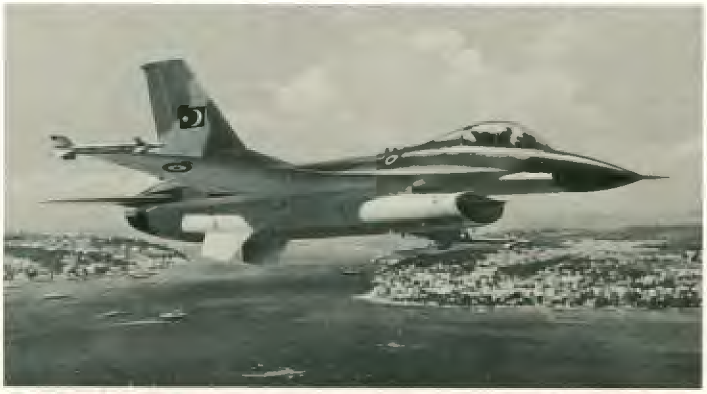
*Israeli F-16's flew their delivery flights to Israel bearing US markings. These were temporarily applied in water color over the Israeli Star of David and were removed following the arrival of the airplanes in Israel. General Dynamics*



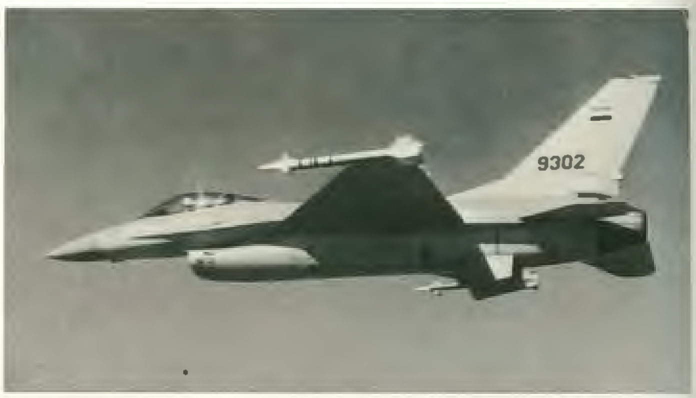
*The Egyptian Air Force began receiving its first F-16's in March of 1982, following turn-over ceremonies the preceeding January. F-16A, 9301, the first Egyptian F-16, allocated Air Force serial number 80-0639, is shown during photo session over Fort Worth countryside. General Dynamics*



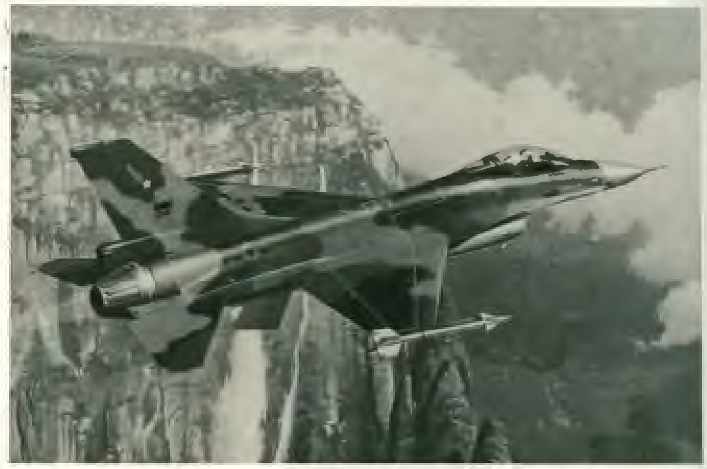
*Another view of F-16A, 9302, with General Dynamics test pilot John Fergione in the cockpit, shows that this airplane is equipped with the new increased-area horizontal tail surfaces. General Dynamics*



*The Turkish air force has recently expressed strong interest in the acquisition of as many as 300 F-16's. No firm commitment has been made as of March, 1982. General Dynamics*



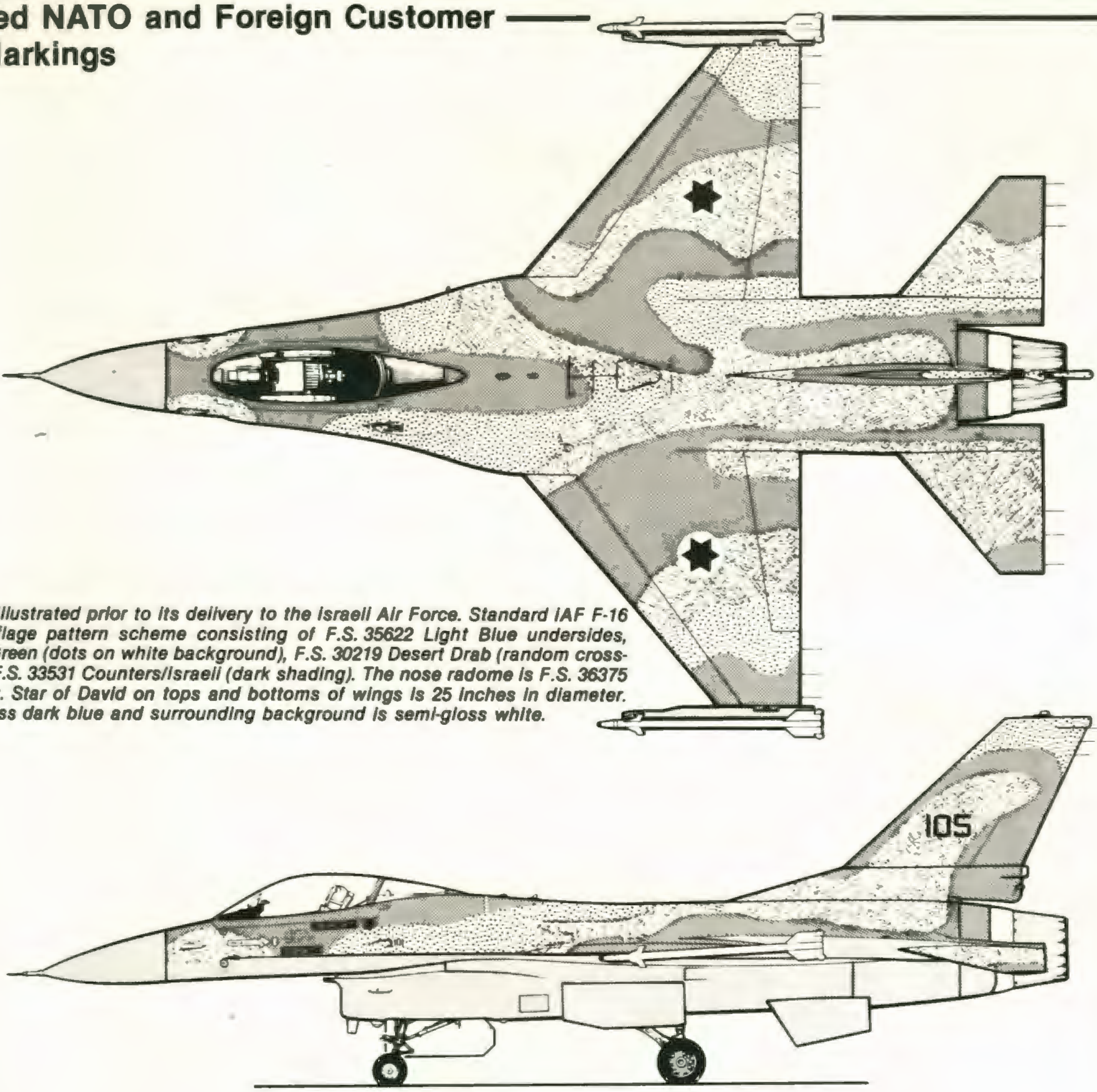
*Second Egyptian F-16 was F-16A, 9302. In March of 1982, the Egyptian government received permission to buy an additional 40 F-16's bringing the total confirmed Egyptian buy to 80 aircraft. The second buy will consist of F-16C's and F-16D's with MSIP modifications. The first aircraft are scheduled to be delivered in late 1985. General Dynamics*



*One of the most recent F-16 buys has been that of Venezuela. Though the first Venezuelan F-16 won't be delivered for several years, this illustration is the first to show the markings of the FAV aircraft. Note that FAV F-16's will apparently be late model MSIP versions with the Norwegian drag chute housing and other modifications. Other F-16 buys that have been tentatively confirmed as of March, 1982, include Pakistan and Korea. General Dynamics*

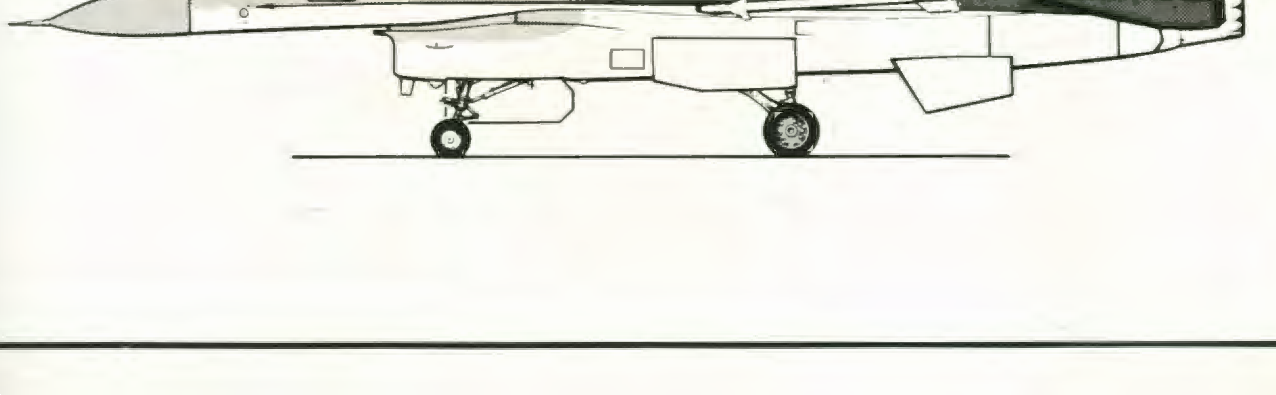
*Greece is representative of the many countries that have expressed interest in the F-16. Though a commitment has yet to be made by the Greek government, interest in the airplane remains strong. Another country that has recently initiated the groundwork for an F-16 buy is Spain. As of March, 1982, the Spanish government had narrowed its replacement fighter choice down to the F-16 and the McDonnell Douglas F-18. A final decision is expected to be made in the late summer of 1982. General Dynamics*

# Selected NATO and Foreign Customer F-16 Markings

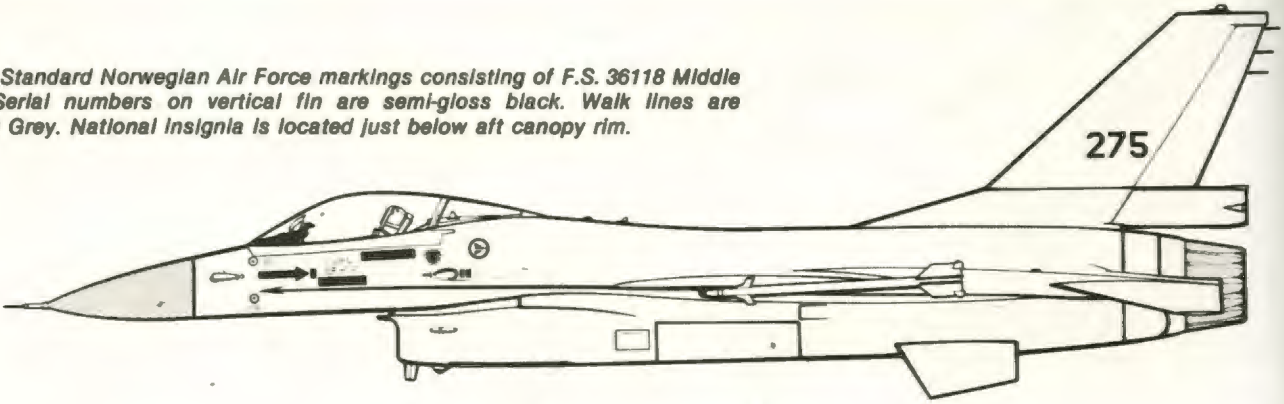


**F-16A,** *105: Illustrated prior to its delivery to the Israeli Air Force. Standard IAF F-16 random camouflage pattern scheme consisting of F.S. 35622 Light Blue undersides, F.S. 34258 A-4 Green (dots on white background), F.S. 30219 Desert Drab (random cross-hatching), and F.S. 33531 Counters/Israeli (dark shading). The nose radome is F.S. 36375 Underbelly Grey. Star of David on tops and bottoms of wings is 25 inches in diameter. Star is semi-gloss dark blue and surrounding background is semi-gloss white.*

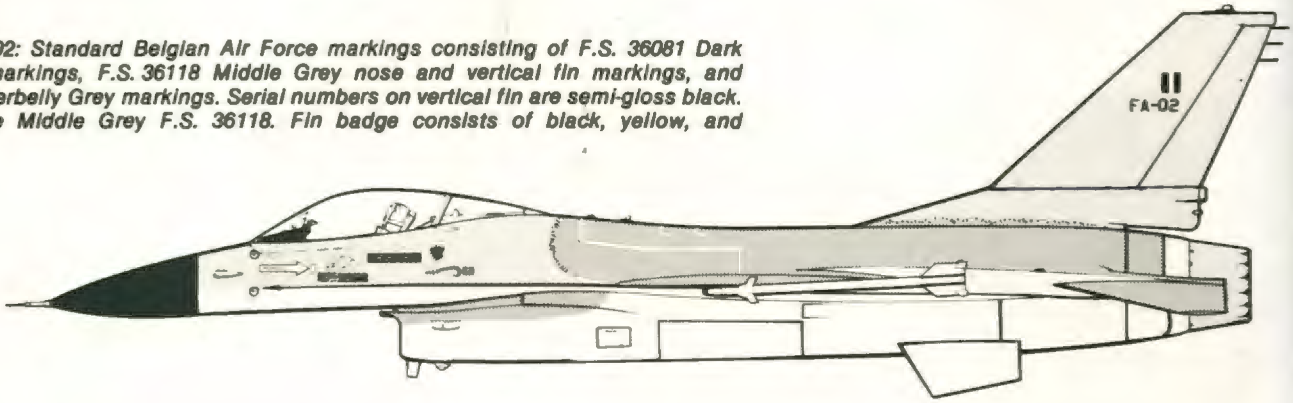
**F-16A,** *9301: Illustrated prior to its delivery to the Egyptian Air Force. Standard EAF F-16 markings consisting of F.S. 36118 Middle Grey nose and upper surface saddle markings, and F.S. 36375 Underbelly Grey markings everywhere else. Serial numbers on vertical fin are semi-gloss black. Roundels on wing upper and lower surfaces. Egyptian flag on vertical fin.*



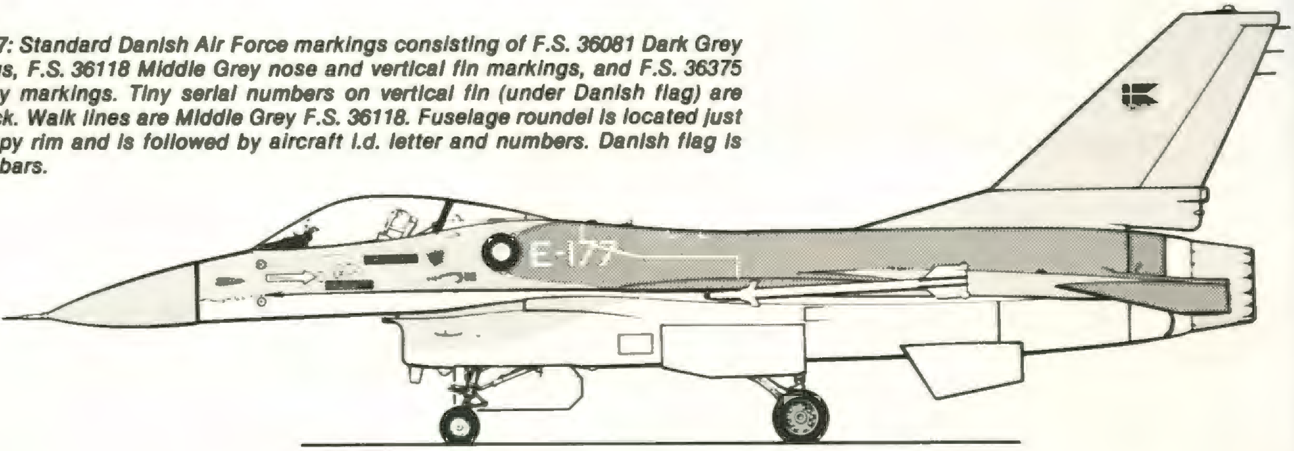
**F-16A,** *275: Standard Norwegian Air Force markings consisting of F.S. 36118 Middle Grey overall. Serial numbers on vertical fin are semi-gloss black. Walk lines are F.S. 36081 Dark Grey. National insignia is located just below aft canopy rim.*



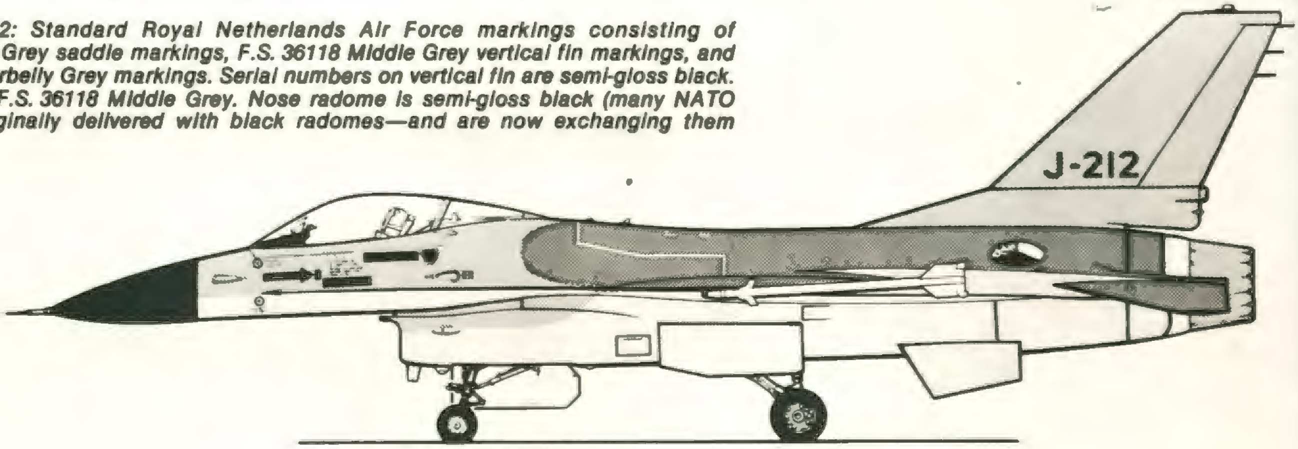
**F-16A,** *FA-02: Standard Belgian Air Force markings consisting of F.S. 36081 Dark Grey saddle markings, F.S. 36118 Middle Grey nose and vertical fin markings, and F.S. 36375 Underbelly Grey markings. Serial numbers on vertical fin are semi-gloss black. Walk lines are Middle Grey F.S. 36118. Fin badge consists of black, yellow, and red stripes.*



**F-16A,** *E-177: Standard Danish Air Force markings consisting of F.S. 36081 Dark Grey saddle markings, F.S. 36118 Middle Grey nose and vertical fin markings, and F.S. 36375 Underbelly Grey markings. Tiny serial numbers on vertical fin (under Danish flag) are semi-gloss black. Walk lines are Middle Grey F.S. 36118. Fuselage roundel is located just below aft canopy rim and is followed by aircraft i.d. letter and numbers. Danish flag is red with white bars.*



**F-16A,** *J-212: Standard Royal Netherlands Air Force markings consisting of F.S. 36081 Dark Grey saddle markings, F.S. 36118 Middle Grey vertical fin markings, and F.S. 36375 Underbelly Grey markings. Serial numbers on vertical fin are semi-gloss black. Walk lines are F.S. 36118 Middle Grey. Nose radome is semi-gloss black (many NATO F-16's were originally delivered with black radomes—and are now exchanging them for grey ones).*



# CHAPTER 10

# THE NAVY AND THE LIGHTWEIGHT FIGHTER

In the early days of the Air Force lightweight fighter program it became apparent to proponents of the lightweight fighter philosophy (most notably the "Lightweight Fighter Mafia") that there was an obvious demand for a similar aircraft to fulfill certain Navy mission requirements. There was, in fact, according to "Mafia" member Everest Riccioni, a Navy version of the "Mafia" operating deep within the bowels of the Naval Air Systems Command.

The birth of this "Mafia" mirror image had been brought about by a number of events, not the least of which was a decision on the part of the Navy to forge ahead with yet another extraordinarily complex and expensive fighter, the VFX. This program, the end result of a decision to avoid acquisition of the problem-plagued bi-service General Dynamics F-111 (the Navy's version was designated F-111B), was soon to become the F-14—and as such, was to become the most complex and expensive fighter airplane in history.

With the birth of the F-14, certain factions within the Navy began to awaken to the fact that the service had two serious problems: (1) its airplane, at over $30-million a copy, was quickly and noisily eating up the Navy acquisition budget; and (2) there was a strong move on in the Congress calling for an increased force structure (which, as has already been noted, was also affecting the Air Force).

Various Congressmen and Senators had begun openly advocating larger numbers, primarily out of fear that the Soviet Union's military arsenal was growing at such a fast pace, that all the sophistication in the world, no matter how advanced, could not defeat it.

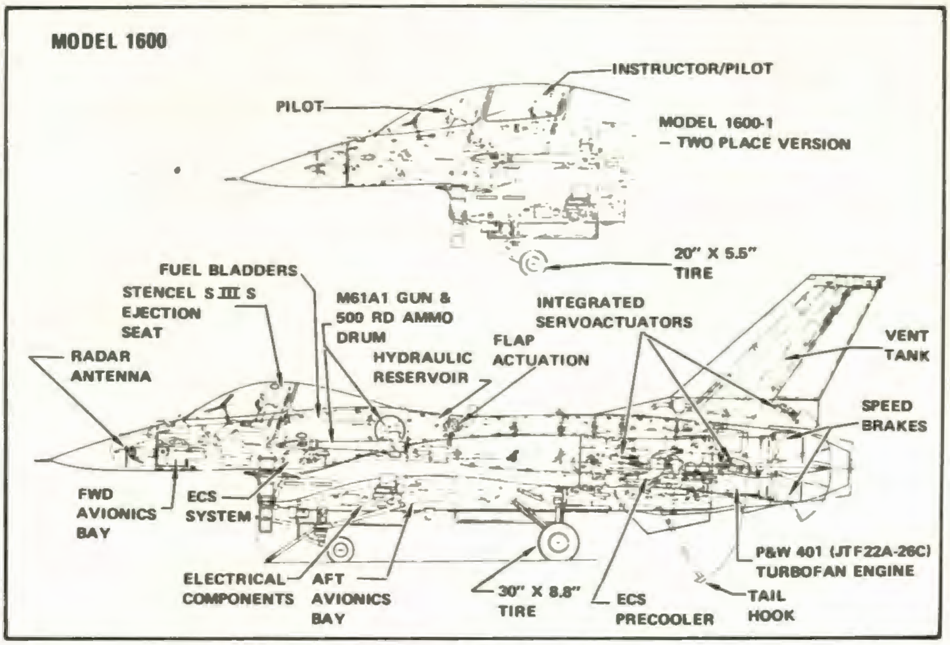
For the Navy, this interest in increased numbers spelled only one thing—sooner or later the service would be forced to look beyond the F-14; and there was every chance that the end result would be forced acquisition of a less complex and, in the Navy's opinion, less capable aircraft.

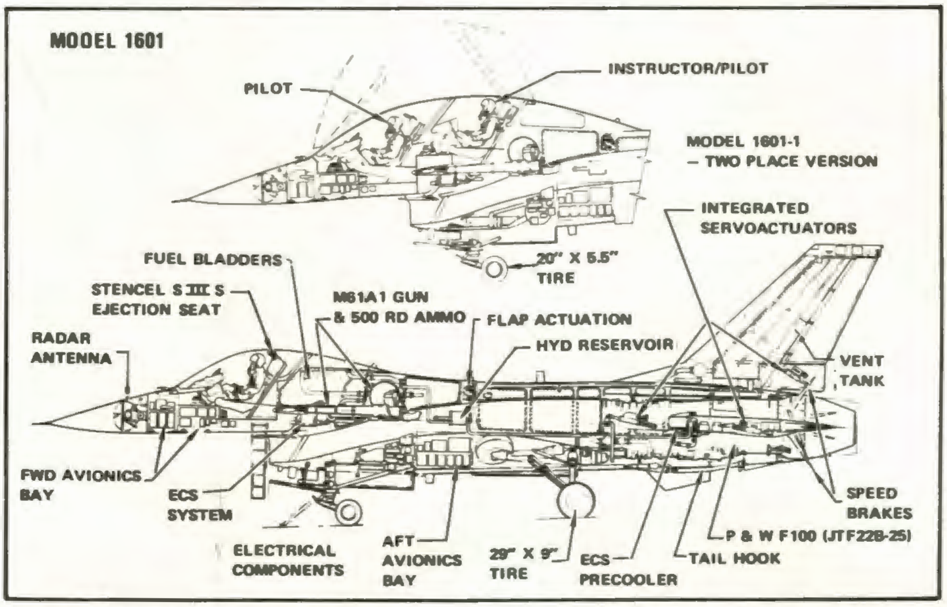
In the summer of 1973, James Schlesinger took over as the new Secretary of Defense. He was not long in becoming embroiled in the controversy surrounding the lightweight fighter philosophy and through good fortune, he was also not long in being introduced to members of the "Lightweight Fighter Mafia". The philosophy expounded by this group made serious sense to Schlesinger and in short order he became both a proponent and a ramrodder.

Schlesinger, within weeks of his taking office, mandated that both services (the Air Force and the Navy) would start giving serious consideration to lightweight fighter designs and in fact, would begin preliminary work calling for proposals from the industry.

In August of 1973, the Navy was instructed by Congress to pursue a study calling for a lower cost alternative to the F-14, and the following month, they were ordered to request proposals from industry. Several Navy study groups had anticipated the mandate and were well underway with studies of their own by the time the official dictum was released. Unfortunately, like many of their predecessors, these inbred study teams were still of the opinion that any F-14 alternative would have to be equipped with a Beyond Visual Range (BVR) armament system. This, of course, meant a radar-guided air-to-air missile.

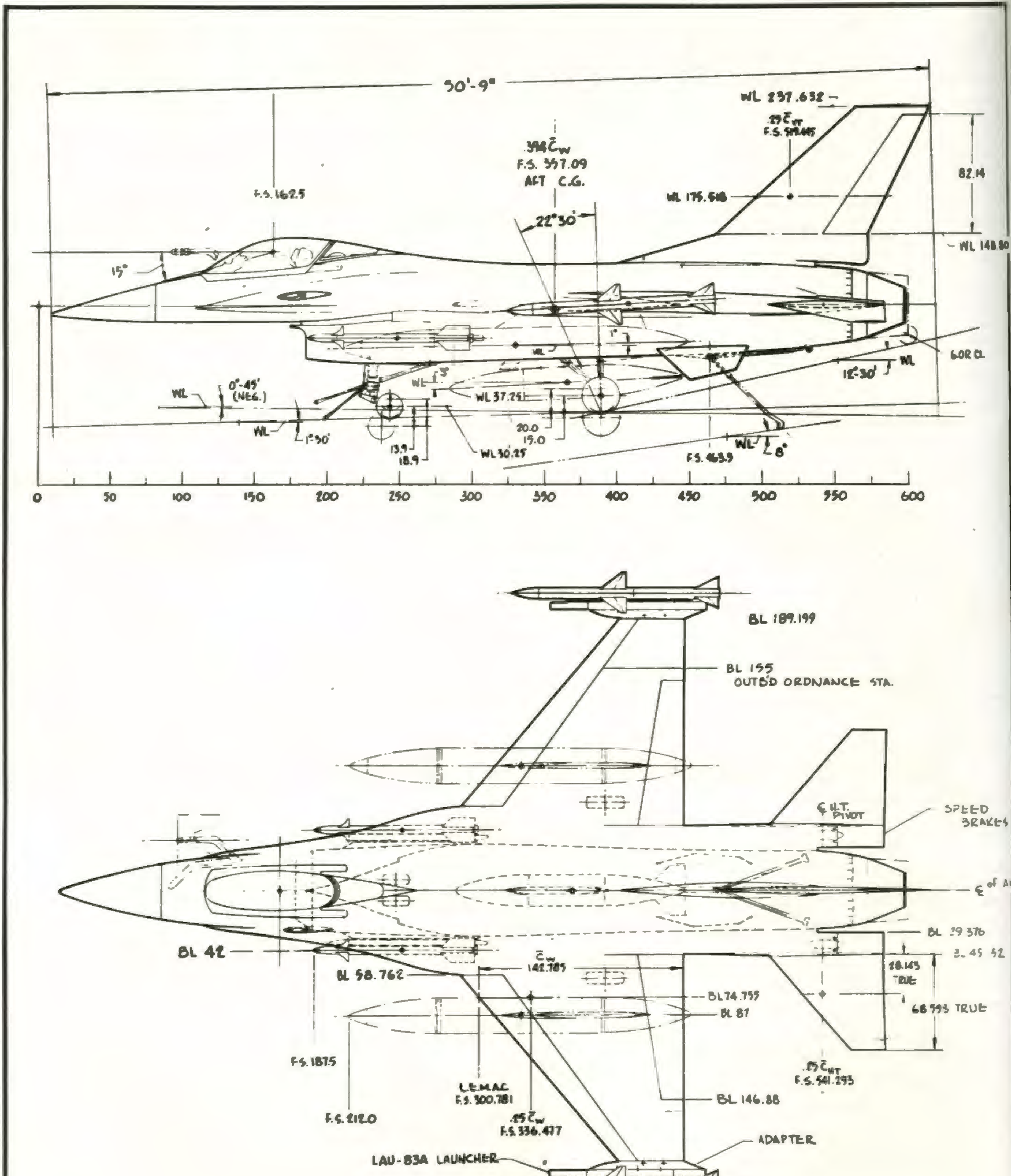
The "Lightweight Fighter Mafia", from the



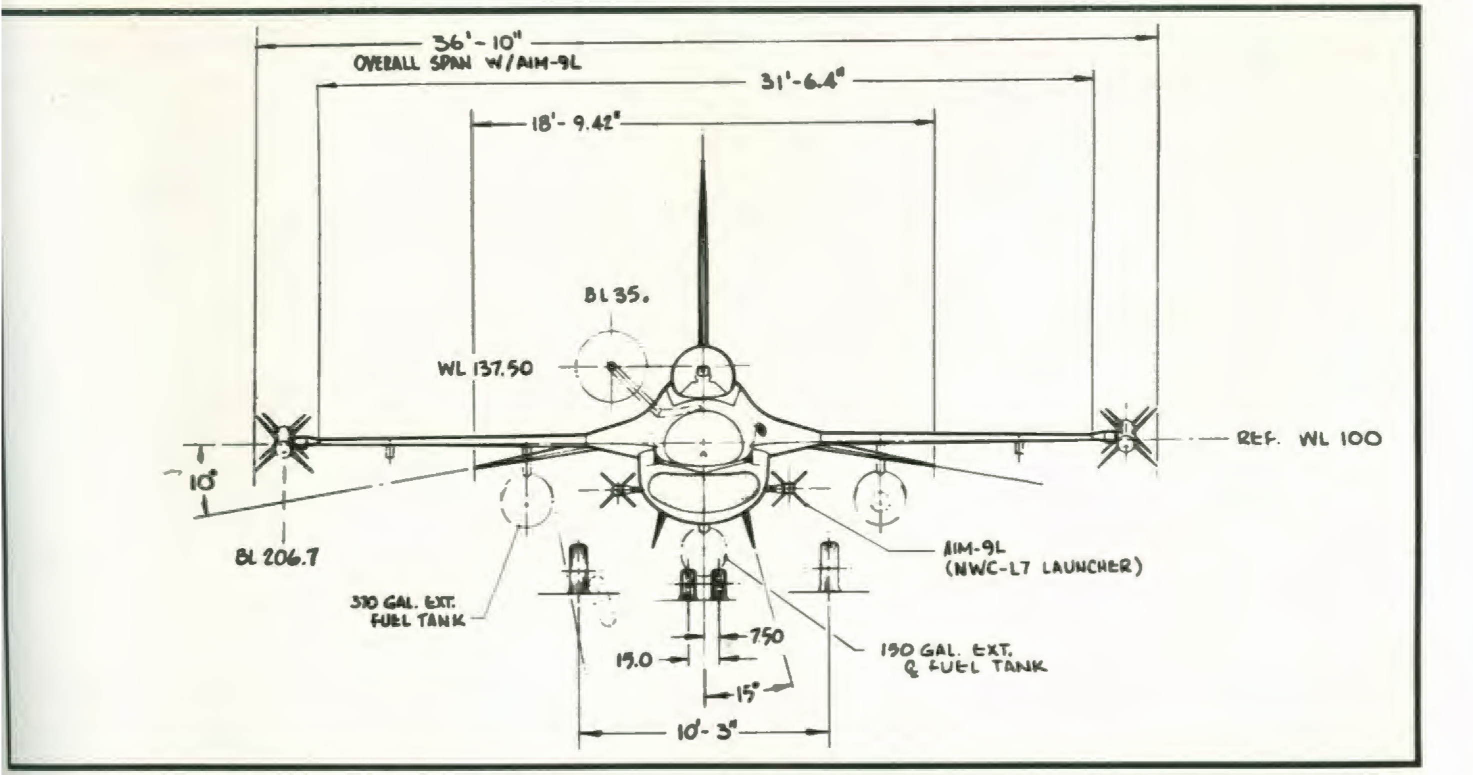


*Two of the more important Navy F-16 proposals, stemming from work that involved the combined efforts of Vought and General Dynamics, were the Model 1600 and Model 1601. Note elevated cockpits and strengthend landing gear (also note that the nose gear has two wheels instead of one). Vought Corporation*

*Model of Model 1601. Vought Corporation*



*Three-view drawing illustrating early Model 1600 study with Sparrow missiles on wingtips, Sidewinder missiles on intake mounted launch rails, and the Navy-required side-mounted inflight refueling probe. Vought Corporation*

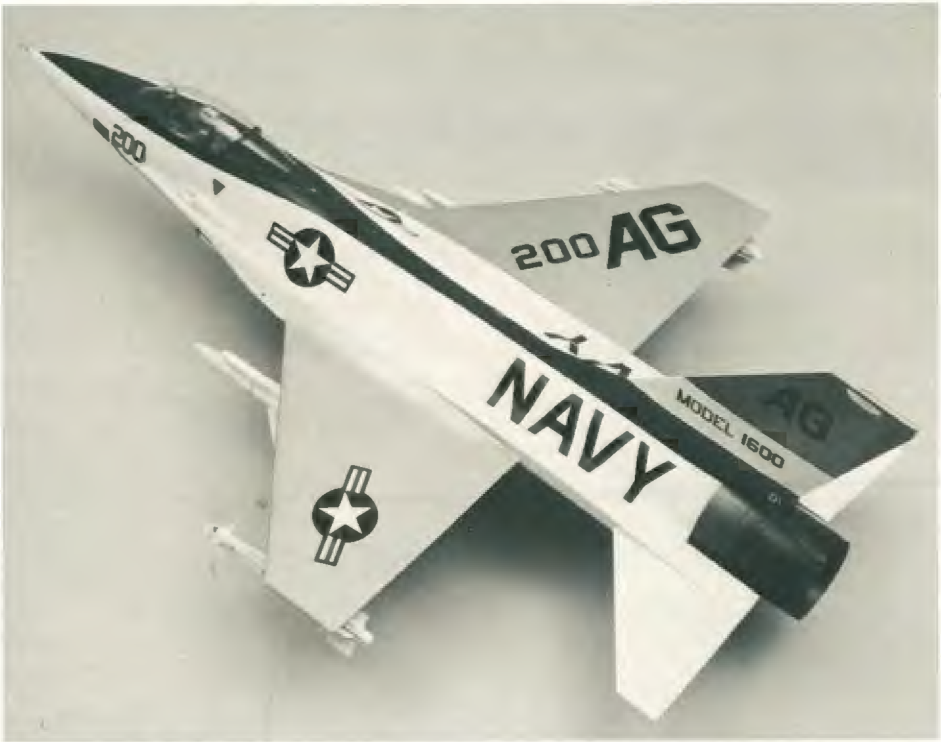


very beginning, had been dogmatically opposed to this weapon. Their reasons were as follows: (1) its excessive cost; (2) its effect on aircraft performance (a radar guided missile system and its BVR radar requirement means that the carrier aircraft will have to be equipped with a large radar dish—which adds weight and increases its frontal area; in order to overcome these two factors, larger engines are required which, in turn, mean more fuel and still more weight; performance is degraded accordingly); (3) the lack of effective Identification Friend or Foe (IFF) equipment necessitating visual identification of the enemy before consummating a launch; (4) its exceptionally poor performance record; (5) the fact that extreme evasive maneuvering by the carrier aircraft can, and often does, break the missile lock-on; and (6) radar guided missiles take time to stabilize during lock-on and thus commit the carrier aircraft to the vulnerability envelope for an unacceptably long period of time.

The Navy maneuvered its way through a number of additional studies and finally presented a proposal to the Congress and the Secretary of Defense calling for an austere, "stripped" version of the F-14, known as the F-14X. This airplane deleted the AIM-54 *Phoenix* missile system but retained the AIM-7 *Sparrow*. It was, so the Navy claimed, the best and cheapest solution to the increased force structure problem.

Congress and Schlesinger disagreed. On May 10, 1974, the House Armed Services Committee deleted the Navy's request for $34-million to start their new VFAX program which called for a totally new fighter to complement the F-14, and instead suggested that the Navy consider adopting one of the two Air Force lightweight fighters then undergoing preliminary flight testing at Edwards AFB.

The Navy, of course, reacted adversely to this proposal, but following additional attempts to push the VFAX program through, quietly capitulated to the Congress and Schlesinger when the following was released by the House and Senate Joint Committee on Appropriations:

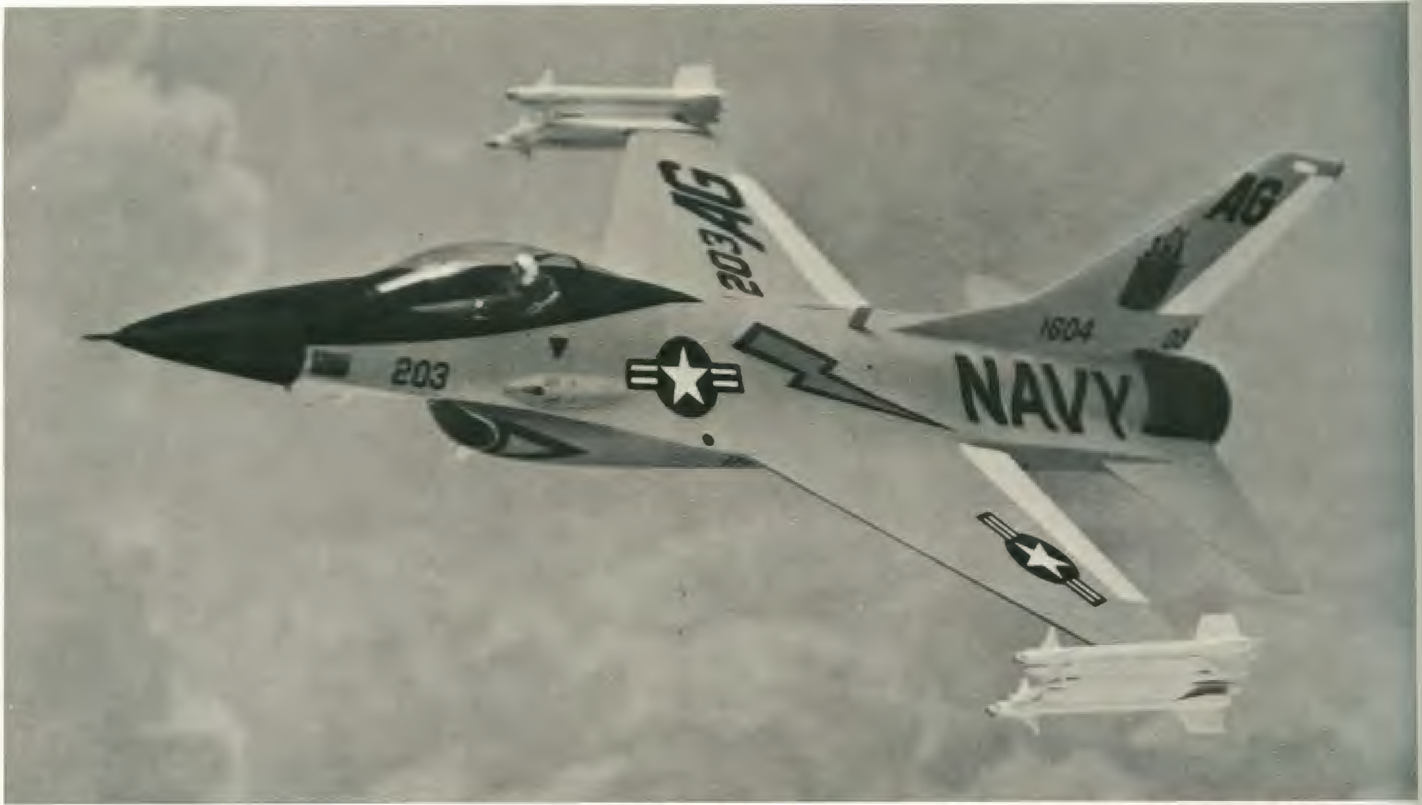


***Model of early Model 1600 configuration. Note mounting of Sidewinders on outboard pylons rather than wingtips, and the inboard mounting of Sparrow missiles. Vought Corporation***

> "The conferees support the need for a lower cost alternative fighter to complement the F-14A and replace F-4 and A-7 aircraft; however, the conferees direct that the development of this aircraft make maximum use of the Air Force Lightweight Fighter and Air Combat Fighter technology and hardware. The $20-million provided is to be placed in a new program element titled "Navy Air Combat Fighter" rather than VFAX. Adaptation of the selected Air Force Air Combat Fighter to be capable of carrier operations is the prerequisite for use of the funds provided. Funds may be released to a contractor for the purpose of designing the modifications required for Navy use. Future funding is to be contingent upon the capability of the Navy to produce a derivative of the selected Air Force Air Combat Fighter design."

Thus it was that the Navy was told to buy whichever airplane the Air Force chose for its ACF requirement. It was a bitter pill for the Navy to swallow and, following the traumatic experience with the Navy F-111B, one that was not likely to go down without a serious fight.

A battle royal did, in fact ensue. And while this was being waged within the confines of the



*Ultimate Model 1600 series design study was the F-16N. Airplane did away with Sparrow missile provisions and incorporated unusual wingtip mounting for four Sidewinder missiles. Navy F-16 program faded rapidly following the demise of this proposal. Vought Corporation*

Pentagon, Northrop reached a partnership agreement with McDonnell Douglas concerning a navalized version of the former company's YF-17 (to be powered by two General Electric F404's), and General Dynamics reached a similar partnership agreement with Vought concerning a navalized version of their YF-16 (to be powered either by a Pratt & Whitney F401 or a General Electric F-101).

The several designs generated from these pairings (most notably the General Dynamics/Vought Model 1600—powered by the F401, the Model 1601—powered by an upgraded F100 known as the F100-3, and the Model 1602—powered by the F101) were obvious extrapolations of the basic Air Force aircraft. Primary differences were numerous, but in general, they included beefed up landing gear, the addition of a tail hook, elevated seats and canopies for improved over-the-nose visibility, increased wing area, slightly shorter fuselages with poorer fineness ratios, and most importantly, more powerful radar systems (with larger diameter radar antennas) to accommodate the Navy's requirement for BVR (air-to-air radar guided missile) armament.

Not surprisingly, the Navy, almost from the very beginning, had taken a strong liking to the YF-17. First and foremost it had two engines, it had what appeared to be plenty of room for airframe growth and expansion, and less obvious, but just as important, it had McDonnell Douglas as its co-prime contractor.

When the final Lightweight Fighter/ADF competition winner was announced by the Secretary of the Air Force on January 13, 1975, the Navy was livid. They had no intention of following the Congressional mandate and they immediately embarked on a program to either kill the Navy lightweight fighter program entirely, or force the Congress to allow them F-17 acquisition privileges.

The Navy did, in fact, eventually get their way. Due in part to the fact that the Navy's requirements were written (perhaps not knowingly) to favor the larger F-17, the navalized F-16, which had evolved through a number of design studies and improvements, including a late March of 1975 submission referred to as the Model 1602B, was killed, and the navalized F-17 became the F/A-18 (for a complete and detailed history of the F-17/F/A-18 program, Jim Stevenson has just completed a book which is to be released soon by *Aero Publishers*).

Not surprisingly, the Navy has kept an observant eye on the progress of the F-16 program during the over half decade that has passed since it brushed off attempts by the Congress to force a Navy F-16 buy. Technical problems with the development and flight test of the F-18 program have led to recurrent inquiries into the wisdom of the original decision and periodically, renewed interest in a navalized F-16 has surfaced.

Though not strictly representing a navalized modification, the F-16/79 Adversary proposal which surfaced in 1980 nevertheless underscores continued Naval interest in the F-16 program. The F-16/79 Adversary project was born as a result of a determined need for intense air combat training for fleet fighter pilots. Dedicated air combat training had been reinstituted in the early 1970's when Viet Nam experience showed that a lack of such training in the 1960's was causing serious problems for U.S. pilots. In a combat arena where kill ratios in excess of 10:1 had been achieved in previous military engagements, U.S. pilots were suddenly finding it difficult to maintain ratios of 1:1.

Air combat training came back into its own in the late 1960's and early 1970's and accordingly, a need for an effective adversary aircraft arose. This mission was adequately filled for most requirements by the Northrop F-5 (particularly by late model F-5E's), but by the late 1970's, this airplane had somewhat outgrown its adversary costume.

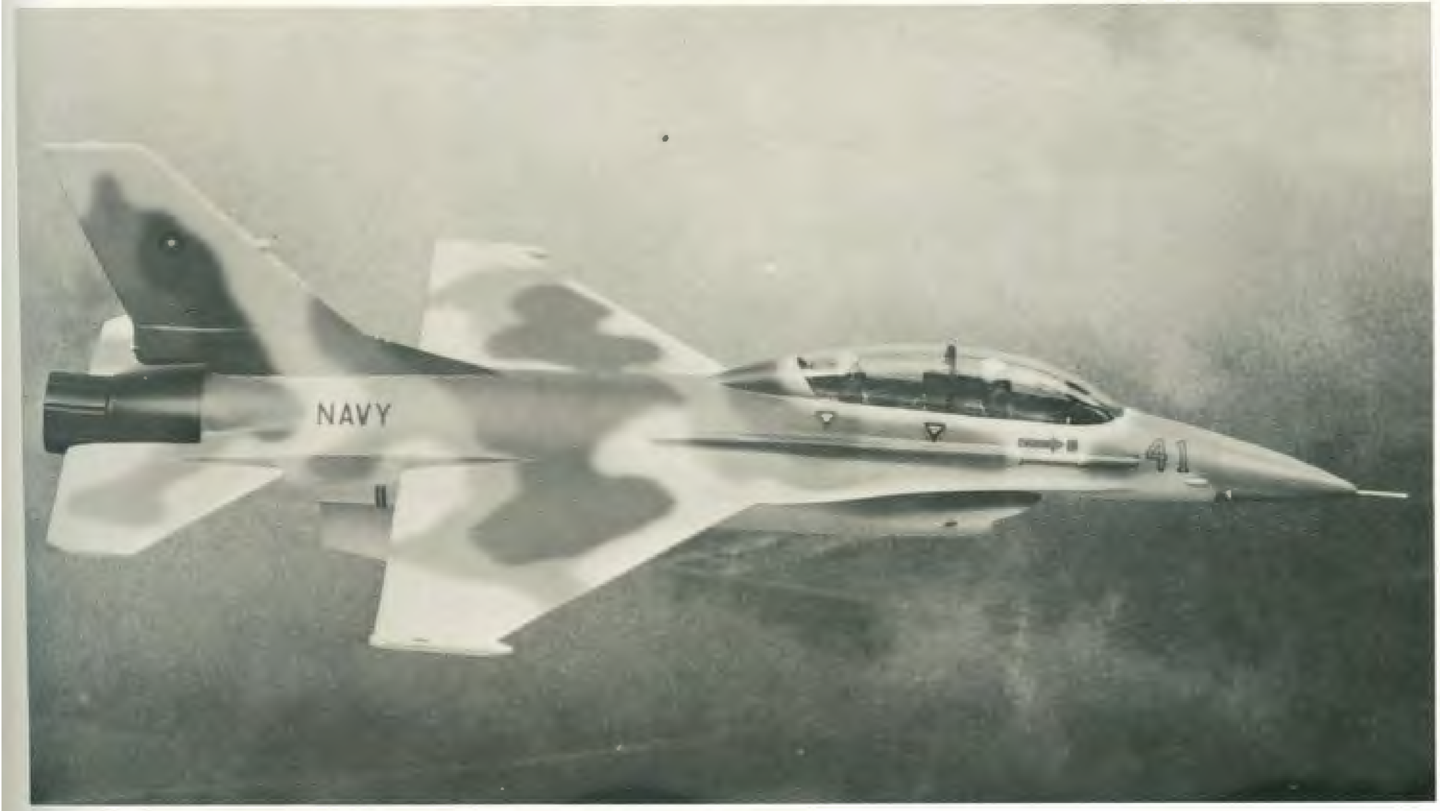
In 1980, the Navy, due in part to the need for an improved capability adversary airplane, and in part to the need to compensate for conventional attrition, began looking for a new adversary fighter. At the time, the Navy's adversary aircraft inventory consisted of 12 F-5E/F's, 3 T-38's (which were scheduled to be returned to the Air Force), 18 A-4E's, and between 30 and 38 TA-4F's (only a few of the latter two types were considered dedicated adversary aircraft).

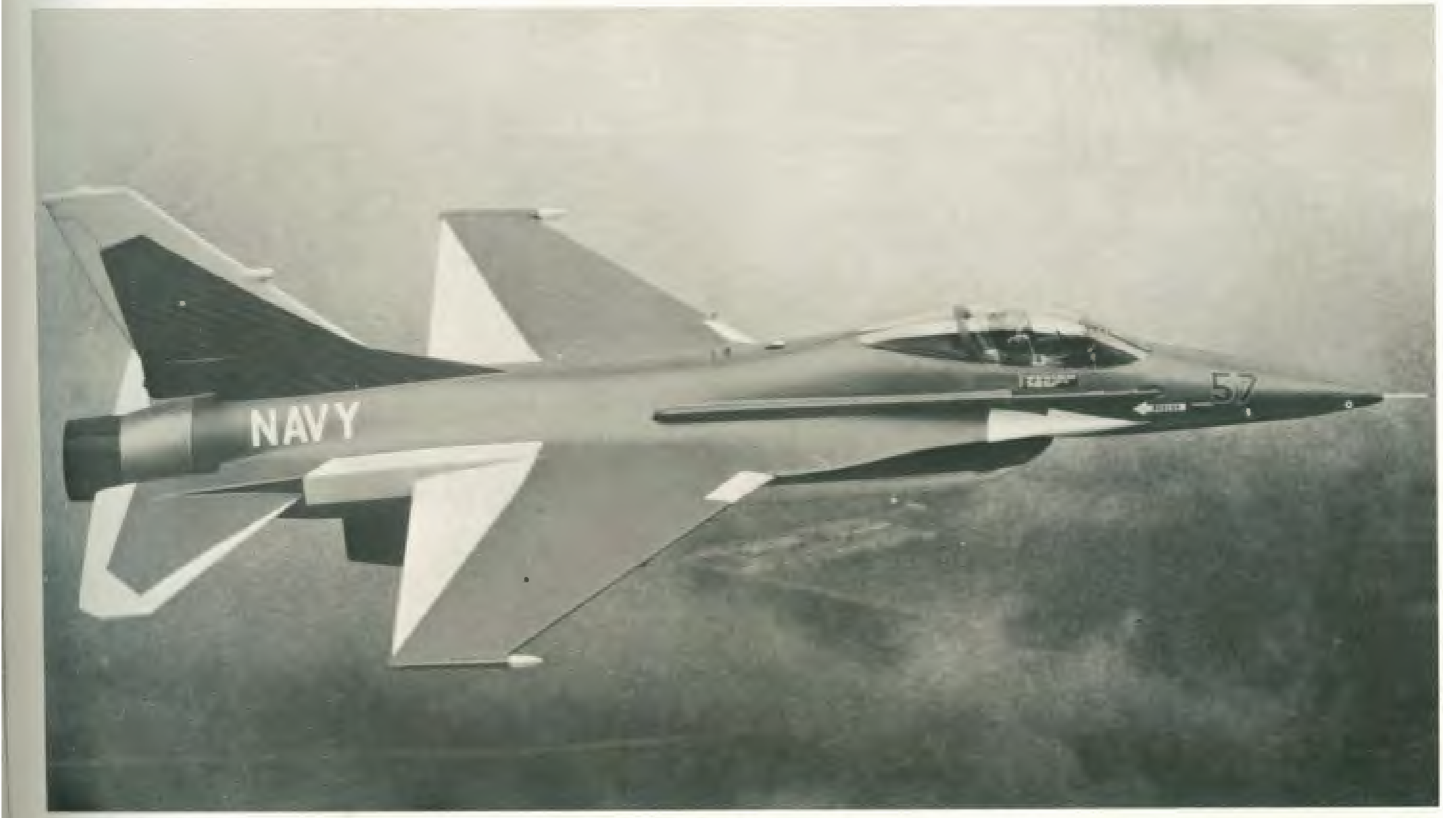
Part of the requirement for any new adversary airplane to enter the Navy inventory (most likely the Fleet Adversary Squadrons: the Navy Fighter Weapons School, VF-126, VX-4, the Marine Air Weapons Training School-1, VA-127, VF-43, VF-171, and VA-45) was that it must match the threat in performance and provide growth capability to include threat avionics (i.e. radar systems and electronic countermeasures).

To fulfill this requirement, General Dynamics in the fall of 1980, proposed to the Navy that the F-16/79 be used. This airplane, with its proven powerplant and exceptional performance throughout the air combat envelope, offered growth potential, a performance margin to match the maneuverability of contemporary Soviet fighters as well as that of forthcoming Soviet fighters, and a reasonable price tag. General Dynamics also noted that the airplane could be used to tow targets and banners, launch drones, and provide other utility services.

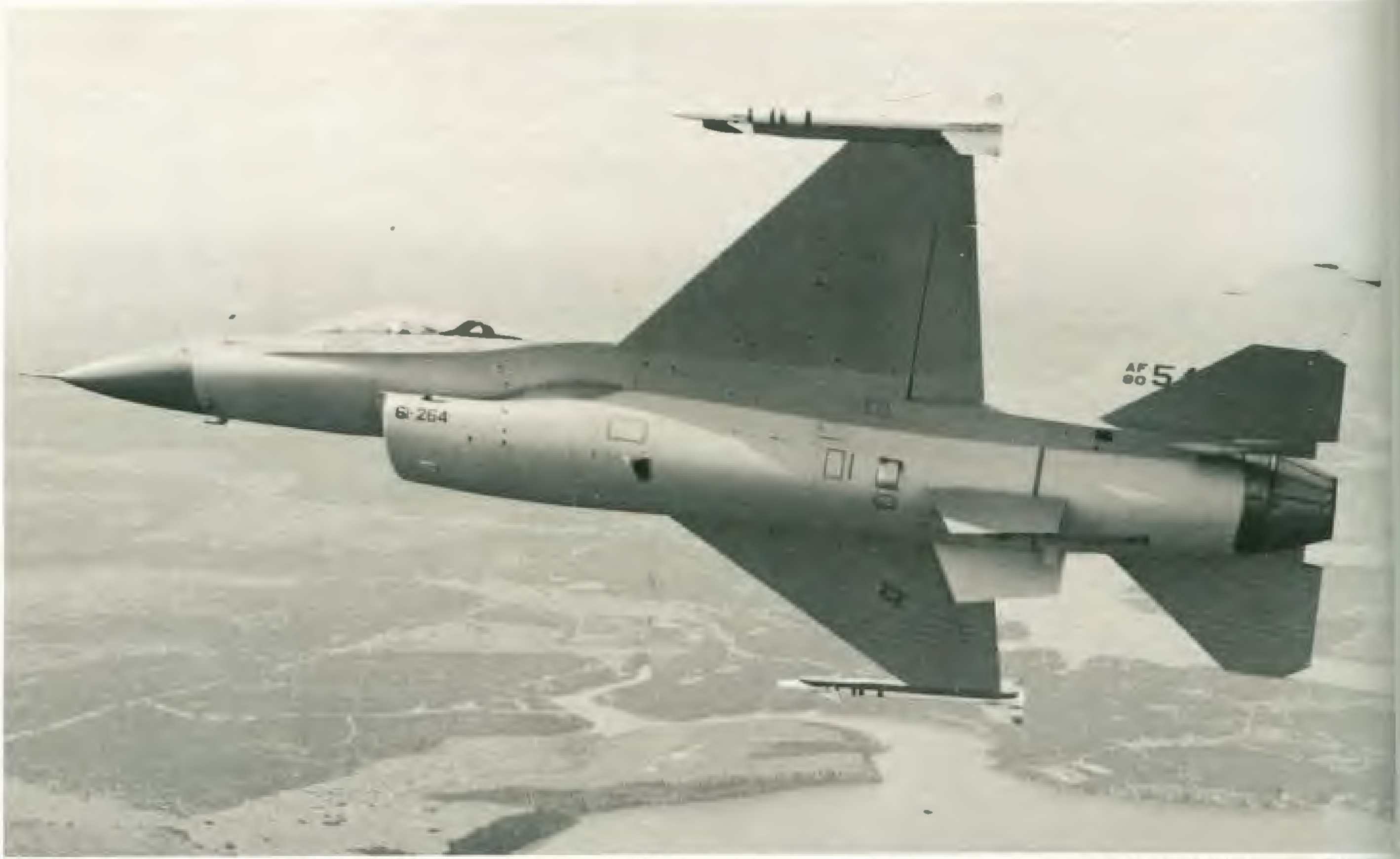
Configuration features of the proposed F-16/79 adversary included installation of a retractable Navy-type probe and drogue inflight refueling system, a selectable flight control computer, a tailored paint scheme, a HUD video recorder, a tail mounted 120-degree field of view video recorder, threat weapon rule-of-thumb envelopes on the HUD, dual radios with selectable communication jamming, and availability in either single or two seat versions. In one form or another the F-16/79 adversary could be made to portray MiG-21's (Fishbed L/N), MiG-23's (Flogger B/E/G), MiG-27's (Flogger D/F), Dassault Mirage F-1's, Tupolev Tu-16's (Badger), Tupolev Tu-22M's (Backfire), anti-ship cruise missiles, tactical airborne jammers, and screen jammers.

Interest in the program eventually led to an evaluation of the prototype F-16/79 by the Navy. This lasted for several weeks and concluded in Navy acknowledgement that the airplane could, indeed fulfill the adversary requirement. Unfortunately, funding constraints curtailed further work on the program and as of the date of this writing, no further action has been taken.

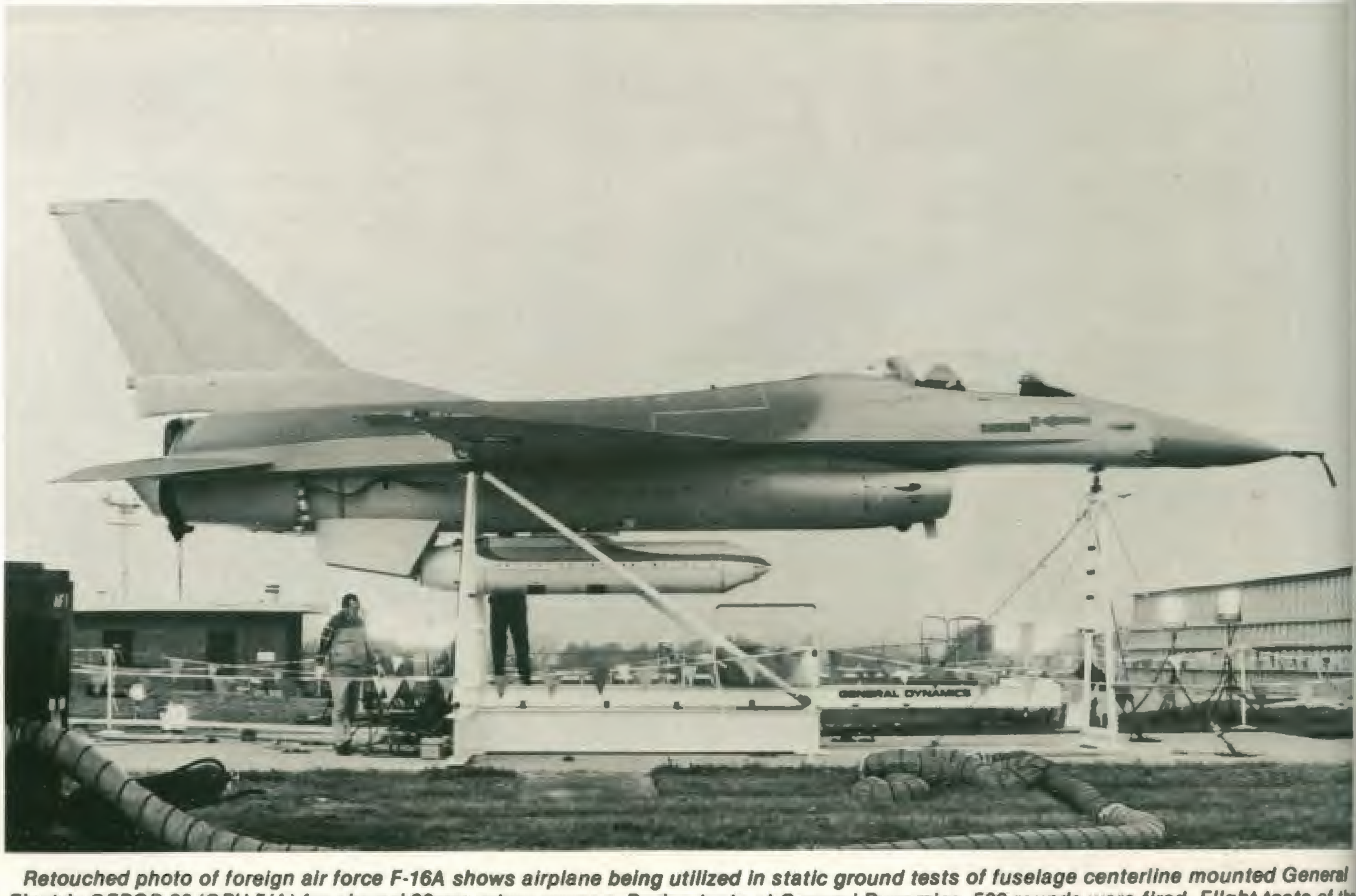




*Renewed Navy F-16 interest came in the form of an aggressor aircraft requirement. F-16/79 was promoted by General Dynamics as being fully capable of meeting the Navy's need for an aggressor airplane. Models illustrate two of several markings variations promoted by General Dynamics at the time of Navy solicitation. Lower model shows the airplane painted to give the visual impression of a Soviet MiG-23. Several similar schemes for other Soviet aircraft were also studied. General Dynamics*

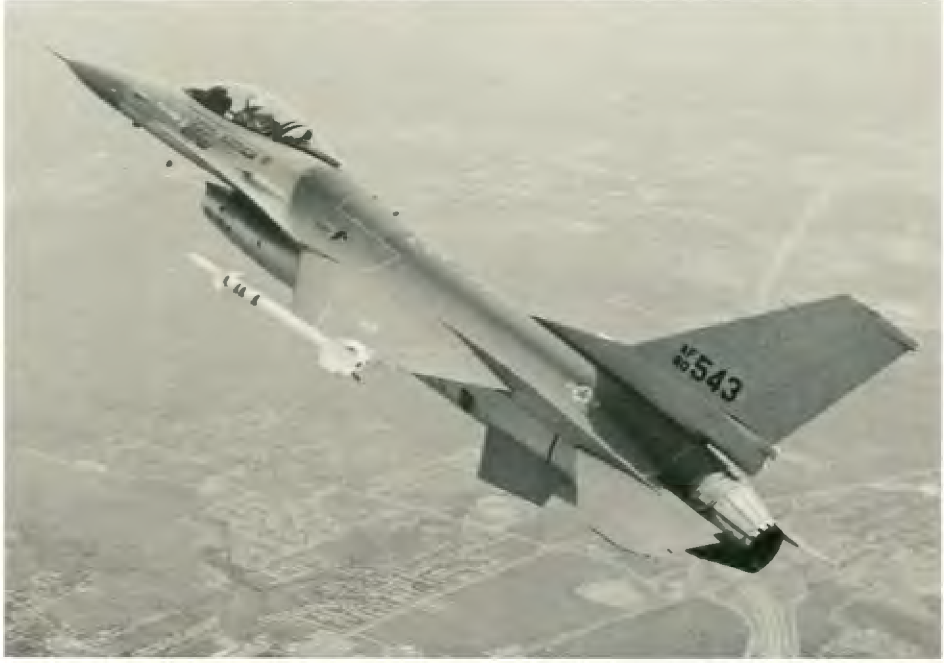


*All F-16's currently in production or planned will incorporate MSIP modifications in one form or another. F-16A, 80-0543, is one of the first aircraft to fly with MSIP I changes. Increased area horizontal tail is most visible external clue. First MSIP I F-16 was delivered in November of 1981 and the first full-up MSIP F-16 is scheduled for delivery in mid-1984. General Dynamics*



*Retouched photo of foreign air force F-16A shows airplane being utilized in static ground tests of fuselage centerline mounted General Electric GEPOD-30 (GPU-5/A) four-barrel 30mm rotary cannon. During tests at General Dynamics, 500 rounds were fired. Flight tests of the GEPOD-30 on an F-16 are planned at Edwards AFB, in 1984. General Dynamics*

# CHAPTER 11
# IMPROVEMENTS AND NEW DEVELOPMENTS


Another view of F-16A, 80-0543, shows increased area horizontal tail. Though it has yet to be officially confirmed by the Air Force, it is virtually certain that all MSIP II and MSIP III F-16's will be designated F-16C and F-16D (for single and two seat configurations, respectively). It is also assumed that MSIP I aircraft brought up to MSIP II and MSIP III standards will be redesignated F-16C/D. General Dynamics

## Multinational Staged Improvement Program

In February of 1980, under Engineering Change Proposal 350 (ECP 350), General Dynamics received Air Force approval to start work on a series of changes to be integrated into the F-16 airframe and systems which were designed to facilitate the introduction of various advanced avionics and weapons systems at a future date. ECP 350, originally conceived as a means to make the F-16 into a BVR capability fighter, later became the F-16A+ (and F-16B+) program and finally came to fruition under the identification of the Multinational Staged Improvement Program, or MSIP.

On July 1, 1980, General Dynamics received a $15,900,000 contract covering engineering, system integration, and FY81 planning costs. This was the first step in what is now expected to be a $1,450,000,000 program.

The MSIP has been divided into three integration stages. The first MSIP stage, known as Stage I, will apply to 456 aircraft in Blocks 15 and 20. These will occupy General Dynamics production schedules from December of 1981 through November of 1984. The first airplane in the first stage, airframe #330, was originally scheduled for completion in November of 1980, but problems with systems integration delayed this roll-out by several weeks. Aircraft #330 is technically the first of what are now known as Block 15 aircraft. It was preceded by the two prototypes (no Block number assigned), the eight FSD airplanes (again, no Block number assigned), 43 Block 1 aircraft (consisting of 21 F-16A's and 22 F-16B's), 116 Block 5 aircraft (consisting of 89 F-16A's and 27 F-16B's), and 130 Block 10 aircraft (consisting of 89 F-16A's and 27 F-16B's).

MSIP Stage I aircraft will incorporate numerous internal changes, including structural modifications and beef-ups (such as a strengthened intake structure to permit the external mounting of sensor and designator pods on either side of the intake, strengthened equipment racks in the fuselage bay behind the cockpit to accommodate sensor related avionics modules, and strengthened #3 and #7 wing store stations to allow a load increase of 1,000 pounds {permitting each station to carry 3,500 pounds}), wiring for forthcoming systems, sensors, and weapons, and a slightly revised instrument panel. Additionally, a drag chute compartment and configuration will be incorporated that duplicates the drag chute system utilized by Norwegian Air Force F-16's.

To be phased into the production sequence at the same time is ECP 425 which calls for a new slab stabilator of 30% increased area and revised internal structure. This was brought about by (1) the need for increased horizontal tail surface area to offset the unavoidable c.g. shifts and weight gains that will occur when the intake pod mounts are utilized; and (2) by an increasing shortage of titanium and the related long acquisition lead times that have accompanied this shortage.

The c.g. shift has been of particular concern to the General Dynamics engineering team for some time due to the relatively small area of the present stabilators and their marginal effectiveness at high gross weights during the low airspeed portions of landing and takeoff. The increased area of the new stabilator is expected to correct this deficiency, but it has been noted that it will also have a favorable effect on the F-16's capability in air-to-air combat primarily through increases in the departure-free maneuver boundaries.

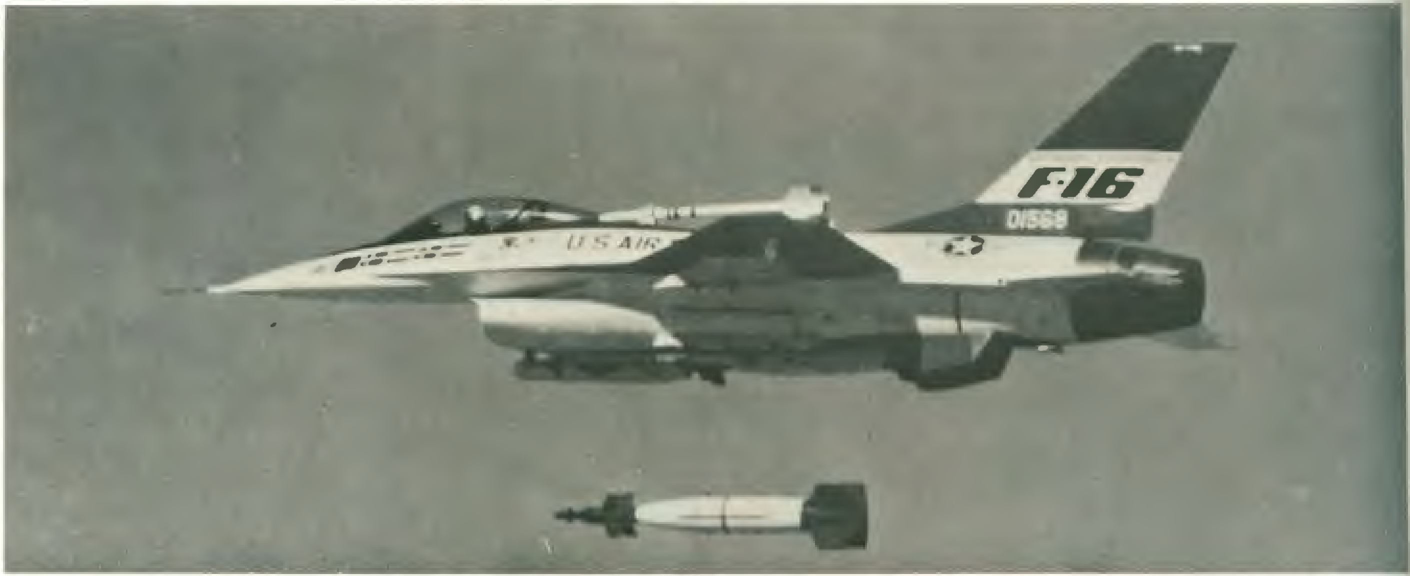
The titanium shortage and long lead times also contributed to the decision to revise the stabilator design and led to a structural, rather than aerodynamic change. As originally built, the unit used a honeycomb core with bonded composite skins and a titanium pivot shaft/sub-spar. The new design calls for graphite epoxy (composite also) top and bottom skins mechanically fastened to a full-depth corrugated aluminum sheet substructure. Though slightly heavier than the original design, this new stabilator will reduce costs and ease the titanium problem somewhat.

A summary of ECP 350 changes follows:

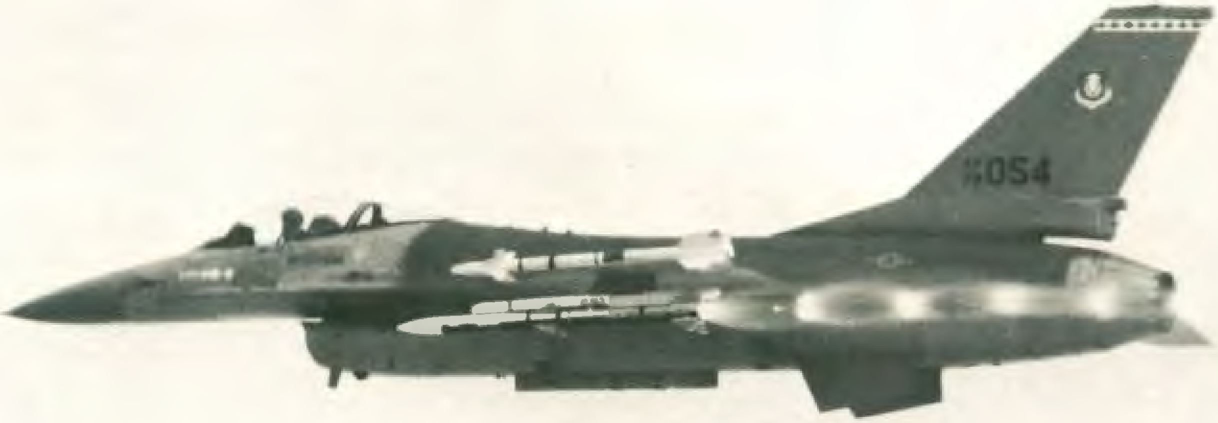
1. Wing structure and wiring for AMRAAM.
2. Inlet hardpoints and wiring for pods (electro-optical and forward looking infra-red on the right and terrain following radar on the left).
3. Cockpit structure and wiring displays (wide-angle raster-video HUD and multifunction displays).
4. Aircraft wiring for expanded core avionics ($D^3$ computer, modified SMS CIU, second mux bus, data transfer unit, and programmable display generator).
5. Selected structural improvements (increased store capacity at wing stations 3 and 7, aft bay strengthening for growth equipment racks, and minor vertical tail provisions for drag chute).
6. Radar altimeter GP 'A'.
7. Min Mod ECS (9 KW).
8. Relocated equipment (VHF radio {remote}, and UHF/L band and threat warning antennas {currently on inlet}).
9. ASPJ forward transmission routing.

The Stage II segment of the MSIP calls for the introduction of several totally new systems, beyond the basic changes called for in MSIP Stage I. The first of these is planned for production line introduction in 1984, with the first aircraft receiving the modifications in July, ahead of the block number change that normally accompanies a production line system introduction such as this. These will be the last of the Block 20 aircraft with the first of the Block 25 aircraft not due off the production line until December of 1984. All Block 25 aircraft will initially be MSIP Stage II standard aircraft, with MSIP Stage III modifications being phased in as they become available.

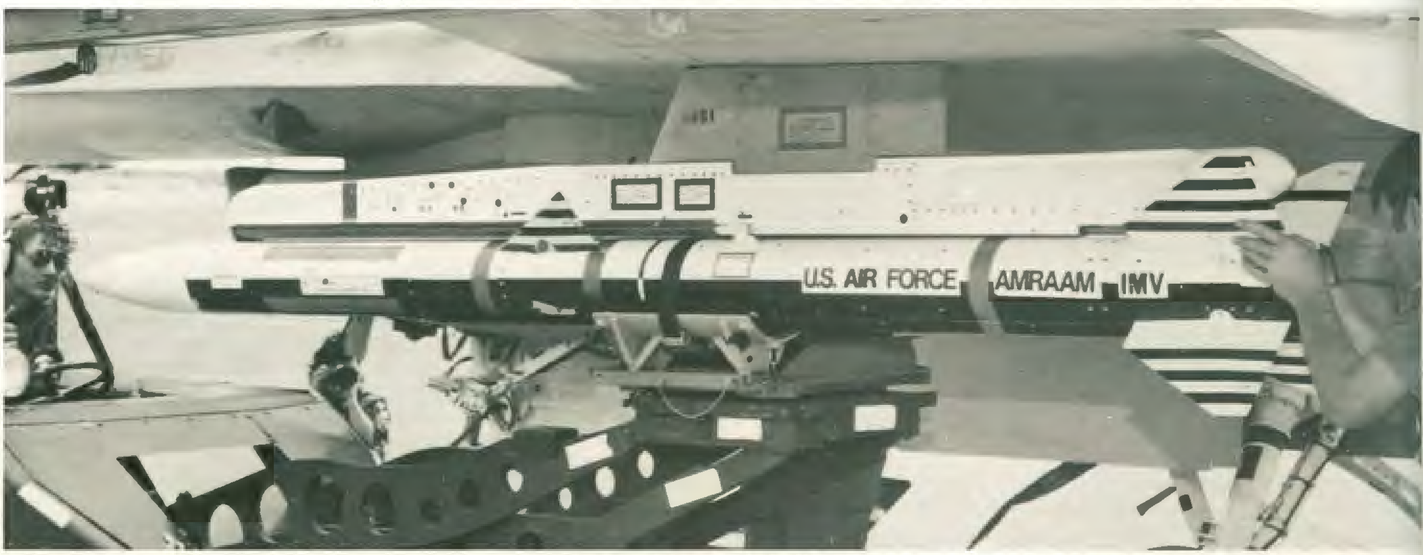
In MSIP Stage II, the changes that will be incorporated include the improved Westinghouse APG-66 radar (with slightly increased range and an improved ability to accommodate the requirements of BVR radar-guided air-to-air missiles such as the forthcoming Advanced Medium Range Air-to-Air Missile {AMRAAM} through a programmable signal processor); a new Marconi Avionics wide-angle Raster head-up display (WARHUD) for use with the Martin Marietta Low-Altitude Navigation and Targeting Infra-Red for Night (LANTIRN) day/ night laser designator which is expected to be introduced during MSIP Stage III; provisions for a radar altimeter (AN/APN-22); provisions for the Automatic Tracking Laser Identification System (ATLIS) II pod; an increased capacity environmental control system; an expanded core avionics ($D^3$ {double speed, double memory, and double multiplex bus}) computer with a 600,000 word memory (five times the computational capability of earlier F-16 computers); an advanced central interface unit (CIU) with a 128,000 word memory; multifunction displays; and upfront communications, navigation, and identification (CNI) equipment.



*The number two YF-16 became the first single seat fighter to achieve accurate, unassisted deliveries of laser guided weapons when it was utilized in the ATLIS II laser designator pod test program. A GBU-10 laser guided bomb is seen being dropped from an altitude of 5,000 feet at a speed of 480 mph. Following drop, pilot made a 4g evasive maneuver. ATLIS II pod is visible under intake section (it is mounted on right side of intake). General Dynamics*



*F-16A, 78-0054, has been used for a number of AMRAAM launches. It is equipped with special externally mounted cameras and a number of onboard non-standard modifications peculiar to AMRAAM requirements. This was first AMRAAM launch in June of 1981 over White Sands Missile Range, New Mexico. Speed was .85 Mach and altitude was 20,000 feet. General Dynamics*



*A USAF weapons crew is seen uploading a prototype Hughes Advanced Medium Range Air to Air Missile (AMRAAM) on a Hughes launcher attached to F-16A, 78-0054. The semi-active radar guided AMRAAM is a major reason for the MSIP modification program. Hughes Aircraft Company*

All MSIP Stage II changes will also be part of MSIP Stage III, which will carry the MSIP program to its ultimate objectives. In Stage III, LANTIRN pods will become available for operational deployment, the Maverick air-to-surface missile and the General Electric 30-mm GEPOD gun pod will become active armament options (on either centerline or wing stations 3 or 7), and the Seek Talk secure voice communications system will be integrated. Additionally, starting in 1985, the Hughes AMRAAM radar-guided air-to-air missile will enter the Air Force inventory, and an internally mounted advanced self-protection jamming system (ASPJ) produced either by a Westinghouse/ITT team or a Northrop/Sanders team will be introduced. Other changes will include the joint tactical information distribution system (JTIDS) and the global positioning system (GPS).

All Stage III aircraft will be Block 25 aircraft. Due to the many modifications and systems additions, these aircraft will be significantly heavier than earlier F-16's with gross weights slightly in excess of 37,500 pounds (versus 35,400 pounds for Block 1, 5, and 10 aircraft). They will also incorporate vastly more complex cockpit systems and greatly revised cockpit layouts and instrument presentations.

Though it has yet to be made official by the Air Force, it is presumed that the Block 25 aircraft will be designated F-16C (for single seat models) and F-16D (for two seat models; General Dynamics, as point of interest has proposed that a special buy of 300 improved capability two seat F-16's as F-16N/WA {Night/all-Weather Attack}, be made by the Air Force, but nothing has come of this).

Export aircraft delivered in 1982 and beyond will be MSIP Stage I configured aircraft. Delivery of Stage II and Stage III configured aircraft to foreign customers will depend on customer requirements and U.S. security considerations.

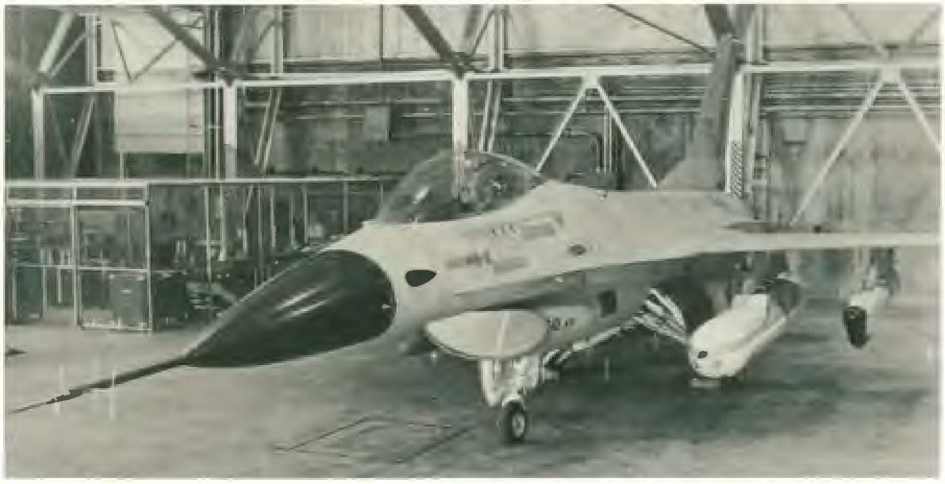
Unfortunately, the advanced technology involved in the MSIP has not come without penalty. For one, the F-16's performance has been (or will be) degraded significantly as engine thrust has remained constant throughout the program while the weight has increased. Additionally, there have been no aerodynamic changes other than increasing the slab stabilator area.

The MSIP also represents a potential supportability nightmare. General Dynamics, in fact, has expressed concern over the impact of the MSIP program on the Air Force support community in providing timely availability of spare parts, tech orders, and support equipment. Solutions to these problems have yet to be generated either by the Air Force or General Dynamics.

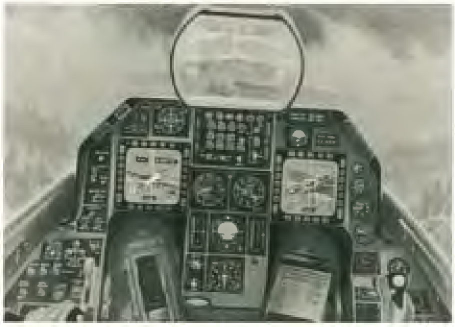
## F-16XL

Once a final design configuration for the production F-16 had been arrived at by Harry Hillaker and his design team, they proceeded to explore other design avenues and options provided by the airplane's unique combination of fly-by-wire, relaxed stability, vortex flow, and modular component structure.

Developments in the technologies of wing design and composite materials allowed wing planforms with features and benefits not previously possible. For example, composites allowed conventional planforms to be increased in area and aspect ratio (span), providing a higher subsonic lift-to-drag ratio at the same weight as an aluminum wing. The unique stiffness properties of composites were found to hold promise of solving the inherent aeroelastic problems of swept-forward wings, and

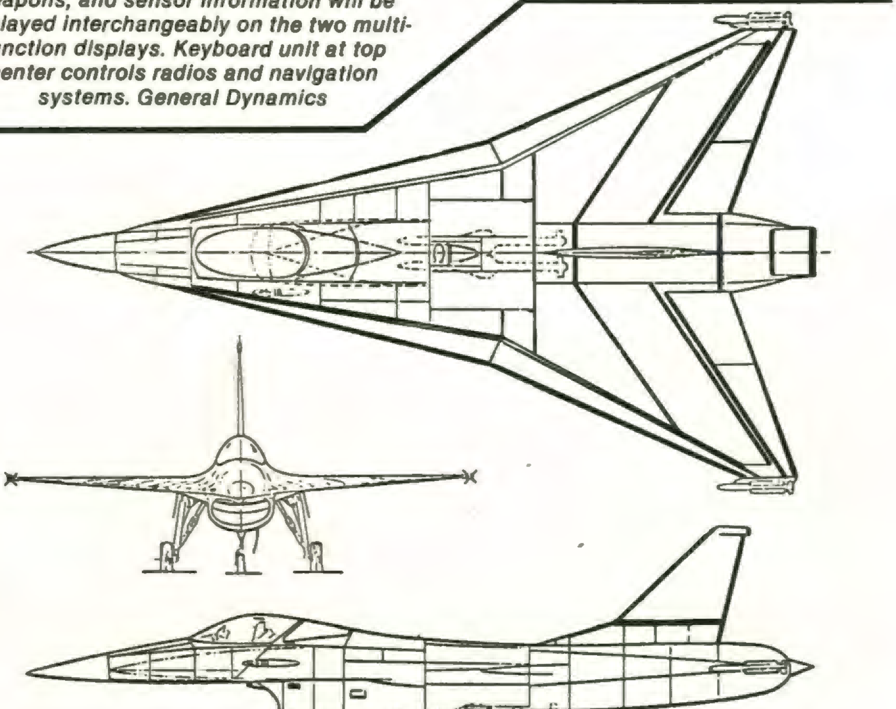


*In 1981, a GEPOD-30 was experimentally mounted under the left wing of the number 5 FSD F-16, F-16A, 75-0748. The pod was neither fired nor flown at the time. Normal mounting for the GEPOD-30 is expected to be the fuselage centerline pylon. Note the ALQ-119 ECM pod on outboard wing pylon. Air Force*

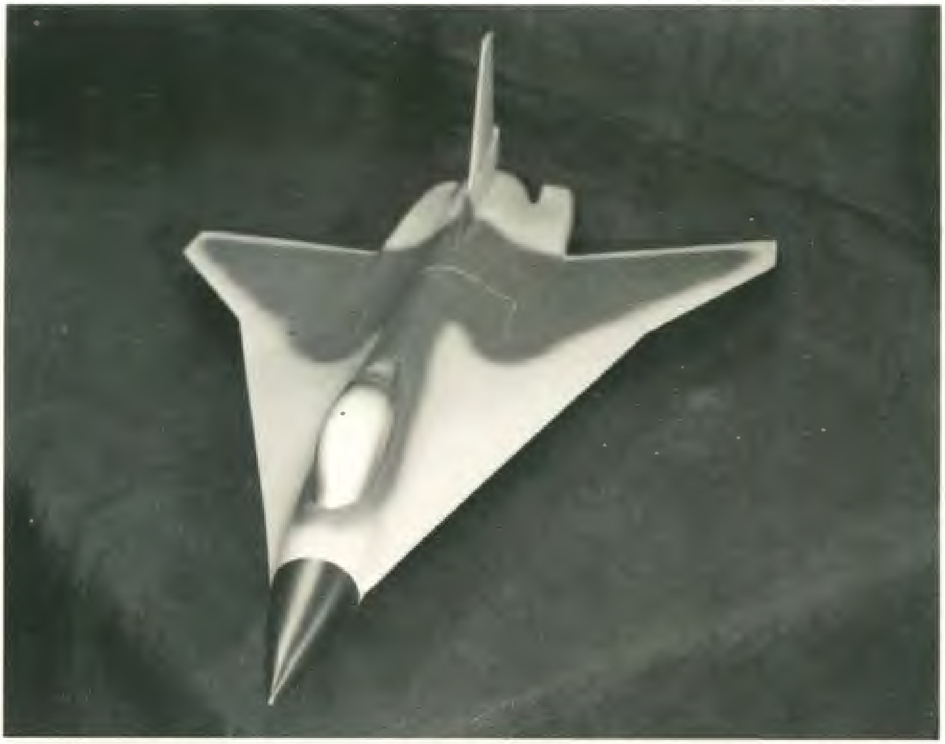


*Late series MSIP F-16's will be equipped with the new wide-angle raster HUD (which provides four times the instantaneous viewing area of the older F-16 HUD) and advanced cockpit displays. Critical flight, weapons, and sensor information will be displayed interchangeably on the two multi-function displays. Keyboard unit at top center controls radios and navigation systems. General Dynamics*

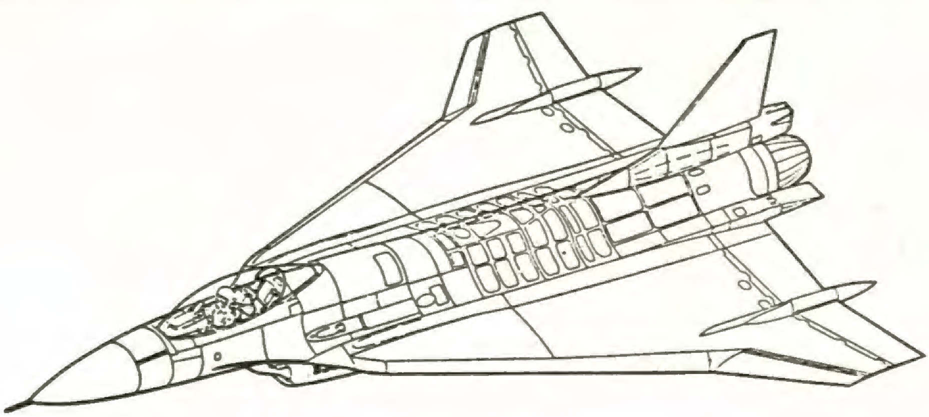
*Pave Penny laser energy sensing units for target acquisition is mounted on right side of F-16A intake. All MSIP configured aircraft will incorporate pod mounts on both intake sides. General Dynamics*



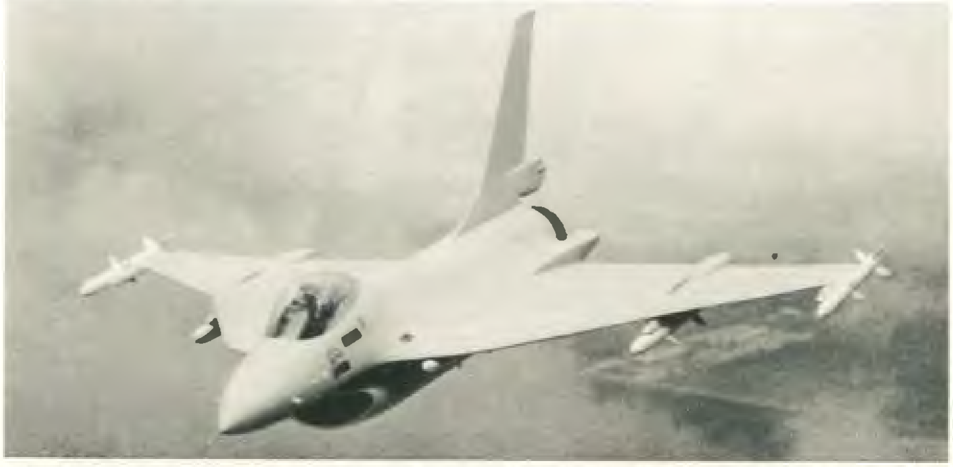
*General Dynamics worked closely with the NASA in developing the F-16XL "cranked arrow" delta wing. This August, 1978, three-view shows an early F-16 600 sq. foot delta wing configuration with a 2-dimensional exhaust.*



*Another early delta F-16 study was this double delta configuration tunnel tested by the NASA. Note camouflage scheme reminiscent of the dark grey on medium grey seen on the number 3 FSD aircraft, F-16A, 75-0747.*



*First illustrations of the delta wing F-16 project to appear publicly included this drawing of the original F-16XL project. Though it does not differ greatly from the F-16XL as it is being built, the use of an F-16A horizontal tail surface for a vertical tail surface is quite noticeable. General Dynamics*



*Final F-16XL configuration shows a rather complex wing design and a stock F-16A vertical fin. Airplane, in proposed production form, will have all MSIP modifications to be found in forthcoming advanced F-16A/B/C/D series. General Dynamics*

also to allow fuller exploration of the attributes of delta configurations (higher volumetric efficiency and lower unit weight). The latter wing, in fact, was found to be particularly attractive as it also provided an opportunity to explore the attributes of conformal weapon carriage.

Drawing upon early NASA work pertaining to the delta and semi-delta configurations explored for purposes of supersonic transport utilization, General Dynamics, in late 1976, initiated a design study program to address the Tactical Air Force operational needs of the late '80's and early '90's. They foresaw the need for improved weapon carriage capability, shorter takeoff distances, and better penetration survival.

The project was assigned to Harry Hillaker, who began to explore the F-16's modular design and its adaptability to configuration change (the F-16's fuselage is designed to be stretched at manufacturing breaks to obtain more internal volume, and the wing, with its bolt on attachments, can easily be replaced by one of a different planform).

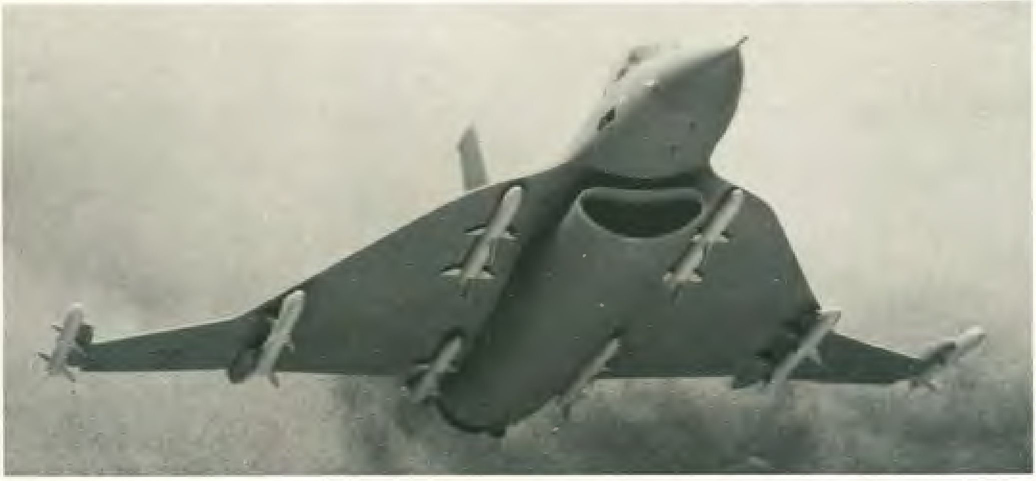
From 1976 through early 1980, a large number of design studies under the auspices of the NASA (Langley) were conducted and a significant amount of wind tunnel time was logged. A total of 149 variables were evaluated including 11 planforms, 15 leading edge flaps, 7 wing tips, 14 canards, 13 forebody strakes, 3 airfoils, 12 vertical tails, 40 vortex fences, 7 spoilers, 5 fuselage stretches, and 21 cambers. Total wind tunnel time logged was 1,169 hours (516 hours low speed, 356 hours transonic, and 297 hours supersonic).

NASA's High Speed Aerodynamics Division was instrumental in defining the wing camber technology and supersonic weapons integration, its Fluid Dynamics Branch provided major contributions in the area of vortex flow/lift optimization, and its Dynamic Stability Branch contributed heavily to improving the low-speed stability characteristics.

Following completion of these studies, it was concluded that the basic F-16 fuselage could be utilized, along with what had become known as the "cranked arrow" delta wing, to form a new fighter of much improved tactical combat performance. In mid-1980, General Dynamics began briefing the Pentagon on its new design, which it was then calling the SCAMP (Supersonic Cruise And Maneuvering Prototype).

General Dynamics claimed a number of significant performance improvements over the standard F-16 for their new airplane, not the least of which were: (1) takeoff and landing distance of no more than 2,000 feet (due to the 66% lift increase promised by the cranked arrow wing); (2) 83% more internal fuel volume; (3) expansion of the 9 g envelope by 119%; (4) a range increase of 44%; (5) an air-to-air mission expansion of from 25% to 125%; and (6) a 90 knot increase in the sea level penetration speed.

Modifications (in effect, changes) to the standard F-16 were to be straightforward. Only two major considerations were actually involved—mating the wing geometrically, and accommodating the wing loads. The F-16's forebody strake, wing/body bending, and aft fuselage shelf made the geometric mating uncomplicated. To accommodate the higher wing bending loads into the fuselage, Hillaker and his design team chose to add a new structural carrythrough component rather than modify the existing carrythrough bulkheads in the center fuselage. This (added between the center and aft fuselage components at a manufac-



*F-16XL provides conformal carriage of weapons for improved cruise drag characteristics. Six AMRAAM's are shown mounted under wing and fuselage. Note compound curvature to cranked arrow wing leading edge. General Dynamics*

turing mate location) saved an estimated 20,500 manhours and added the advantage of increased internal volume (894 pounds of fuel and 10.4 cubic feet of unallocated space).

The cranked arrow wing, constructed of graphite polyimide composites, also offered an improved c.g./payload balance condition but necessitated a change to maintain an adequate c.g./main landing gear relationship (tipback angle). Hillaker was faced with the choice of moving the main gear slightly aft or stretching the forward fuselage. Not surprisingly, he chose the latter as this saved significant manhours and provided an additional 25.7 cubic feet of volume.

As the SCAMP design development program advanced, so did the basic configuration of the airplane. Continual refining of the basic planform and overall design led to a number of subtle changes, not the least of which was a switch from the use of a stock F-16 horizontal stabilator for vertical tail surface duties, to a dedicated unit of swept design (essentially the vertical surface and associated drag chute box that will be seen on MSIP Stage III aircraft).

During the summer of 1980, word of the SCAMP program was leaked to the press for the first time. This revelation had not been suspected by General Dynamics and it forced the company to acknowledge publicly that the proprietary program did, in fact, exist. Not long afterwards, the project was renamed, becoming the F-16XL, and the first official information was released.

Pentagon interest in the program, although enthusiastic, had been developing slowly due in part to the rapidly expanding F-16 program and in part to the lack of available funding. In February of 1980, General Dynamics submitted an unsolicited proposal to the ASD to build two flight demonstrator aircraft by modifying two existing FSD F-16A's. Though this proposal received a favorable evaluation, funding constraints prevented official Air Force support. Subsequently, General Dynamics decided to proceed with the program utilizing company funds. At the same time, the Air Force was asked to provide support in the form of hardware assets for modification.

In late 1980, General Dynamics, following additional F-16XL design development, established a dedicated prototype team led by Vice President and Program Director D. R. Kent. This team was similar to the original YF-16 team, and was created in order to begin the preparation of engineering drawings, design analyses, and manufacturing planning. During the summer of 1981, the two FSD F-16A's (#3, 75-0747; and #6, 75-0749) were returned to General Dynamics to undergo conversion and the program was officially allocated the F-16E designation. The first airplane to arrive, #6, was to become a single seat airplane, and the second airplane was to become a two seat airplane (which, as point of interest, was at one time rumored to be allocated the F-16F designation).

In January of 1982, yet another designation change was made. The Air Force asked that the F-16E designator be reserved for a possible production version of the new airplane and that the two technology demonstrators once again be referred to as F-16XL's.

Current Air Force plans call for an F-16XL flight test program to validate, in flight, the technical and operational benefits of the cranked arrow wing design. This will encompass 225 flight test hours during 180 flights over a period of 15 months. To be demonstrated will be increased range-payload, low weapon carriage drag, expanded angle-of-attack limit, and shorter takeoff and landing distances. Also, at this time, it is proposed that an operational utility assessment in the Red Flag program at Nellis AFB, Nevada be undertaken in order to obtain more meaningful data than is possible from mission analyses and computer models.

Following successful completion of the flight evaluation and test program, one of the F-16XL's (most likely the two-seat airplane) will be flown off against the McDonnell Douglas F-15 Strike Eagle. From this fly-off will come a decision as to whether the F-16E program should be pursued in order to fulfill the requirement for the Air Force's night, all-weather attack aircraft. Some 400 aircraft are needed to fulfill mission objectives.

As of the date of this writing, the prototype F-16XL (apparently still bearing the original FSD F-16A serial number) is in final construction and is due for roll-out in the spring of 1982. First flight is now scheduled for July of 1982.

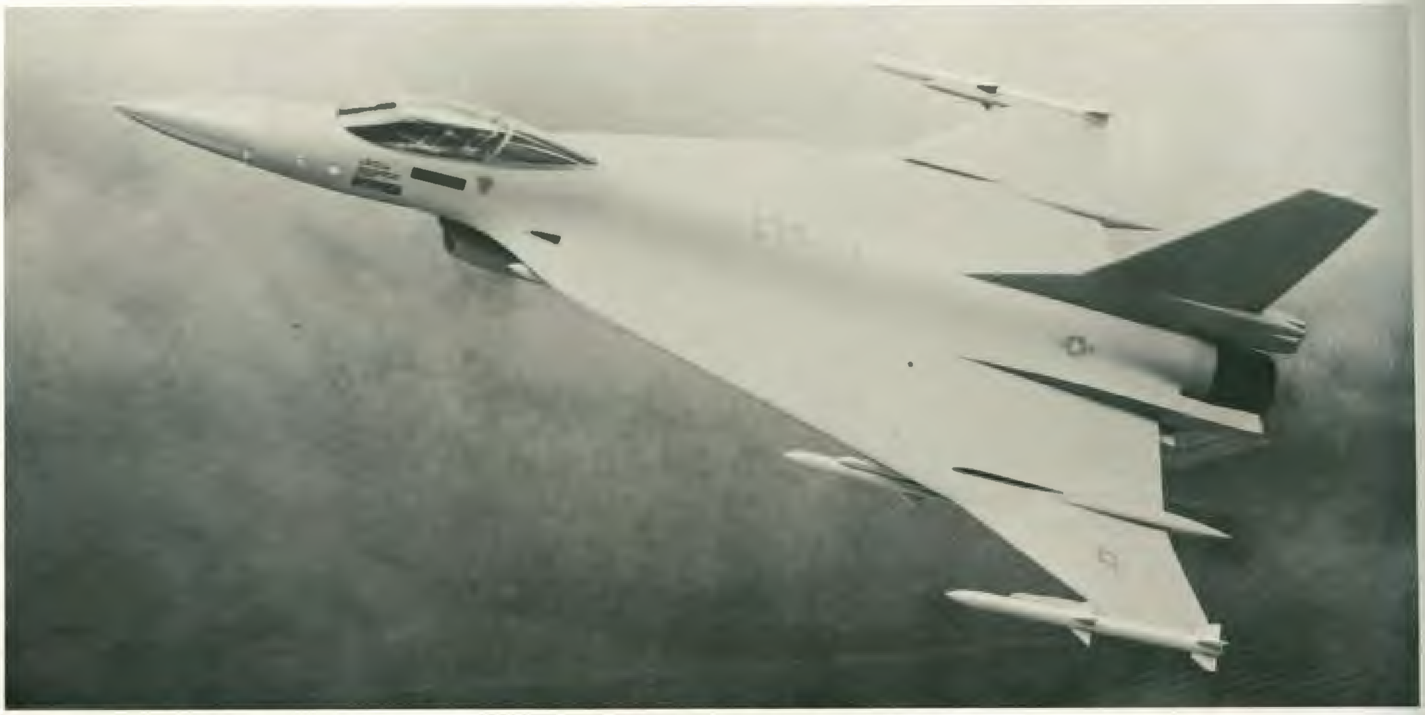
Though official F-16XL data is not yet publicly available, the following is considered accurate:

| | |
|---|---|
| Length | 54' 1.9" |
| Wingspan | 32' 4.84" |
| Wing area | 646.371 sq. ft. |
| Aspect ratio | 1.624 |
| Taper ratio | 0.117 |
| Leading edge sweep | 70-degree inboard, 50-degrees outboard |
| Incidence | 0.65-degrees at the root |
| Twist | 4.104-degrees at station point 136.1 and tip |
| Dihedral | 0-degrees |
| Mean aerodynamic chord (ref.) | 296.398" |
| Leading edge mean aerodynamic chord (ref.) | FS 190.66" |
| Airfoil | NASA 64A (SS41.5-136.1)<br>Modified Biconvex (136.1-tip)<br>cruise/acceleration camber |
| Elevon area | 38.469 sq. ft. |
| Aileron area | 25.664 sq. ft. |
| Leading edge flap area | 18.709 sq. ft. |
| Height | 16' 8.5" |
| Zero fuel weight | 19,608 lbs. |
| Fuel weight (internal) | 12,750 lbs. |
| Takeoff gross weight | 32,358 lbs. |
| Design maximum gross weight | 37,500 lbs. |
| Powerplant | 1 x Pratt & Whitney F100-PW-100(3) afterburning turbofan rated at 25,500 pounds thrust |
| Maximum speed | Mach 2.18 (clean condition) |
| Maximum altitude | 62,500' |
| Maximum range | 3,000 miles |

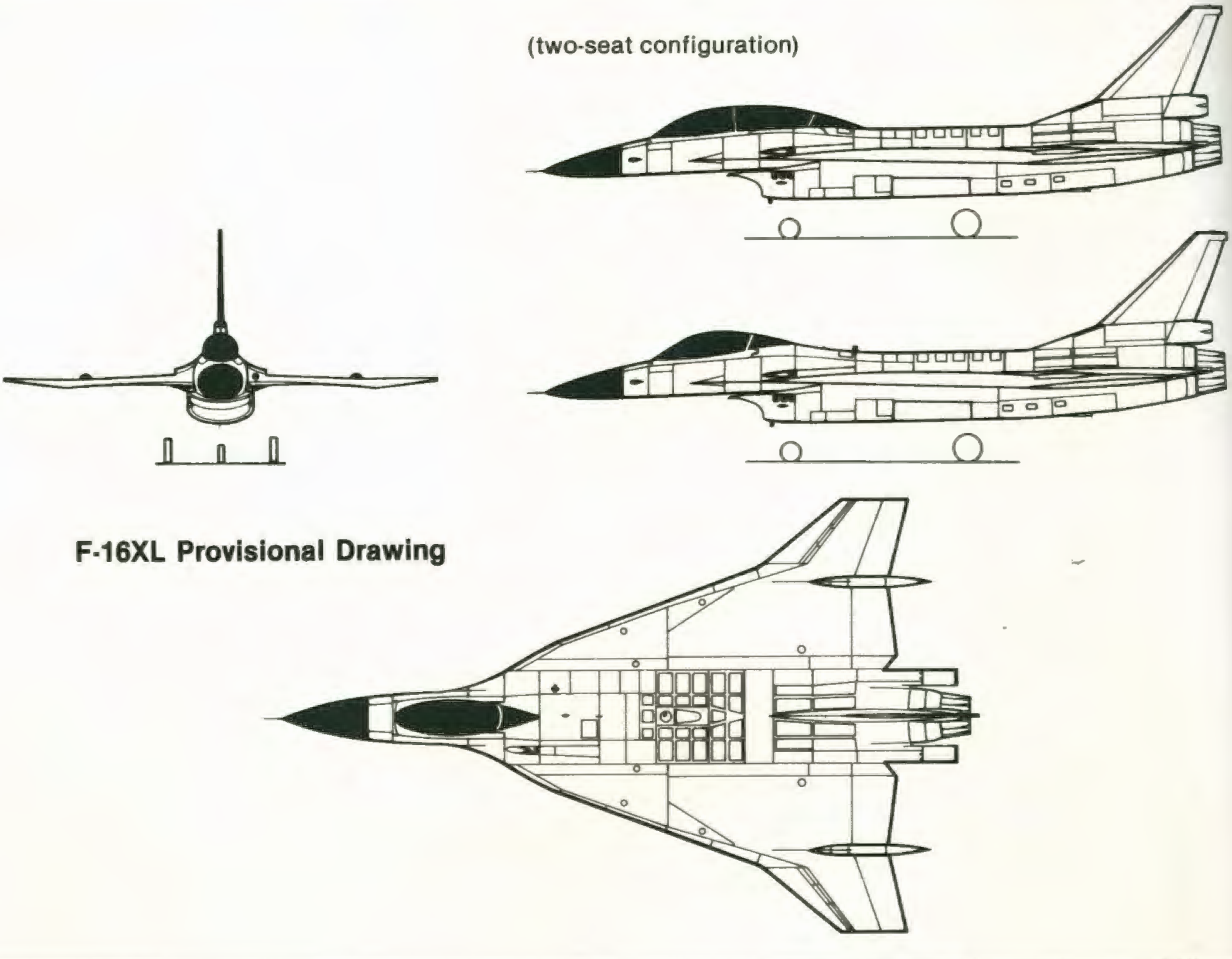
As point of interest it should be mentioned that Congress has recently added $15,300,000 to the FY 1982 defense budget to initiate flight testing of the F16XL. These funds were not requested by the Air Force because the need for the funds came up too late in the budget cycle. This action is considered by General Dynamics to be a strong measure of the interest that the airplane has generated.

The following table indicates the high F-16A/F-16E commonality:

| | |
|---|---|
| Structure | |
| Forward fuselage | 92% |
| Center fuselage | 95% |
| Aft fuselage | 90% |
| Subsystems | |
| Engine accessories | 99% |
| Flight control | 82% |
| Engine start | 100% |
| Emergency power | 100% |
| Electrical | 75% |
| Hydraulic | 82% components<br>60% tubing |
| Fuel | 90% components<br>40% piping |
| Propulsion | 100% |
| Environmental control | 95% |
| Landing gear | 100% |
| Avionics | 100% |



*Small wing fences are visible in this view of F-16XL model. Also note drag chute housing and revised gun port configuration.*
*General Dynamics*



**F-16XL Provisional Drawing**

# CHAPTER 12

# ODD MODS

The following is a listing of various noteworthy F-16 projects that have surfaced during the first decade of the program:

**Reconnaissance Configurations**—Though there is currently no Air Force plan to acquire reconnaissance capable F-16's for service introduction, there has been strong interest expressed in this configuration option for a number of years. Because there will be a need in the late 1980's to begin replacing the Air Force's complement of RF-4C tactical reconnaissance aircraft, a reconnaissance version of the F-16 remains a viable proposition, and in fact, according to reliable sources, a strong replacement candidate.

Early F-16 design studies defined a number of recce system possibilities, including real-time equipment, various nose mounted optional sensors, and a large number of podded configurations. Real-time options included data acquisition and transmission to ground station, and data acquisition and transmission to airborne aircraft plus target designation configurations. Nose mounted optical sensor configurations included cameras mounted in bays just forward of the cockpit (but otherwise having conventional radar-equipped noses), and fully dedicated camera bays occupying the entire nose section (ala RF-101C, etc.).

Podded systems, due to their convenience, were also examined and were found to permit exceptional aircraft flexibility (dedicated pods satisfied specific mission requirements and rapid reconfiguration was available with 30-minute down-load/upload cycle rates), increased sortie rates (reconnaissance system maintenance could be accomplished without aircraft downtime), and reduced operating costs (the reconnaissance requirement could be satisfied with available resources).

Most recently, two basic reconnaissance configurations have been proposed by General Dynamics for Air Force and foreign customer use. These are: (1) A fighter configuration equipped with missionized reconnaissance pods—reconnaissance capability could be provided for either the F-16A or the F-16B with the addition of special purpose mission systems installed in centerline pods. The F-16 would retain full capability for adverse weather operation in the air-to-air and air-to-surface roles and would be utilized for the reconnaissance mission as required by the tactical commander.

And: (2) A dedicated reconnaissance configuration with internal sensors and equipment—either the F-16A or F-16B would be modified to accommodate reconnaissance equipment internal to the aircraft. Essentially the same sensors and equipment carried in the external pod configuration would be incorporated into the nose section of the aircraft and into a special reconnaissance bay located on the bottom of the center fuselage forward of the right main landing gear door. This configuration option would require the removal of the fire control radar set and the M61A-1 rotary cannon. However, self-defense capability would be retained with the wing-mounted AIM-9's and full weapon store carriage capabilities would be retained for visual precision strike.

Control functions for reconnaissance sensors could be easily accommodated in the F-16A cockpit. Space is available on the right-

*Nellis-based F-16A, 79-0338, is flanked by the two F-16 engine testbed aircraft, F-16/101, 75-0745, and F-16/79 75-0752. General Dynamics*

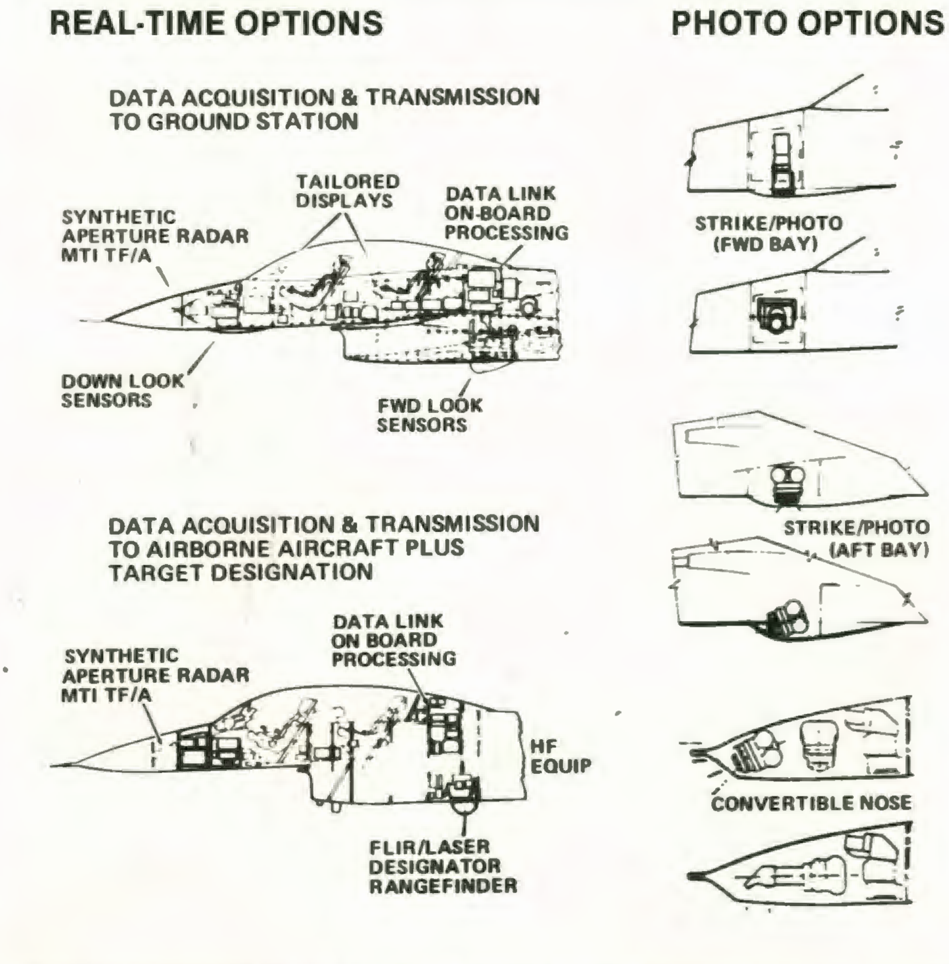
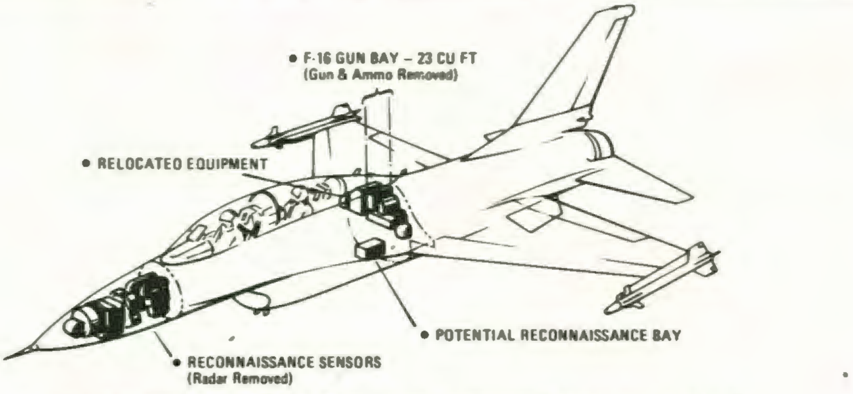
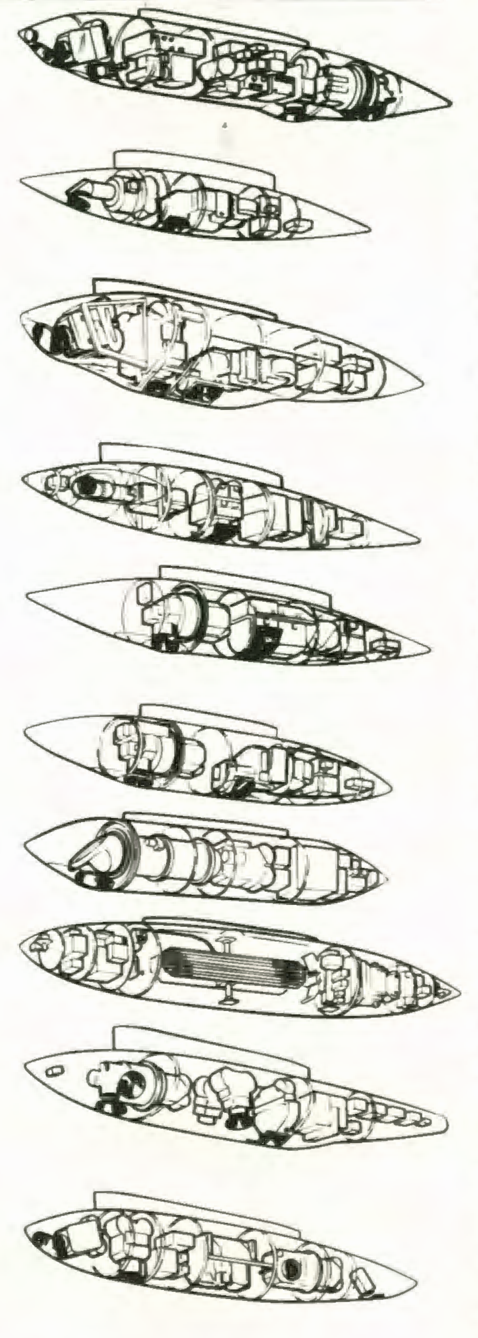

REAL-TIME OPTIONS
PHOTO OPTIONS
DATA ACQUISITION & TRANSMISSION TO GROUND STATION
TAILORED DISPLAYS
DATA LINK ON-BOARD PROCESSING
SYNTHETIC APERTURE RADAR MTI TF/A
DOWN LOOK SENSORS
FWD LOOK SENSORS
STRIKE/PHOTO (FWD BAY)
STRIKE/PHOTO (AFT BAY)
DATA ACQUISITION & TRANSMISSION TO AIRBORNE AIRCRAFT PLUS TARGET DESIGNATION
DATA LINK ON BOARD PROCESSING
SYNTHETIC APERTURE RADAR MTI TF/A
HF EQUIP
FLIR/LASER DESIGNATOR RANGEFINDER
CONVERTIBLE NOSE

*Photo-reconnaissance options for the F-16 include internally mounted equipment options. These have yet to be ordered for production aircraft. General Dynamics*



The design of a dedicated RF-16 configuration requires some modification to the basic F-16 airframe and systems. As with other dedicated reconnaissance aircraft, the multimode radar is removed in order to accommodate the optional sensors and equipment in the nose section.

*The RF-16 dedicated reconnaissance configuration includes photo and infrared sensors. General Dynamics*



**LOW ALTITUDE, DAY/NIGHT POD** — Provides excellent low level to medium altitude coverage. The reconnaissance system consists of a KS-87B forward oblique camera, a KA-56E panoramic camera, an infrared line scanner and a KA-108 frame camera positionable inflight from horizon-to-horizon.

**HIGH ALTITUDE OFFSET POD** — Provides medium altitude flyby/flyover data coverage. The reconnaissance system consists of a modified KS-87B 18-inch focal length side oblique camera (positionable inflight), a KA-93B4 panoramic camera, with four selectable fields-of-view and a 20° sector mode positionable inflight.

**HIGH LOW ALTITUDE PHOTO-IR MIX POD** — The system is designed for a pallet load providing either high or low altitude data coverage within one pod. The low altitude configuration consists of a KS-87B 6-inch focal length forward oblique camera, a KA-56E panoramic camera, a KA-95 panoramic camera with 40 to 190° scan angles selectable, and an RS-700 series IR scanner. A 24-inch focal length KA-93 panoramic camera replaces the IR line scanner and KA-95 panoramic camera to provide the high altitude configuration.

**LOW ALTITUDE POD**— Provides low altitude, day/night flyover data coverage. The system configuration consists of an IR line scanner, a KRb6/24 camera and an 18-inch focal length KS-87B side oblique camera

**OFFSET LOW/MEDIUM ALTITUDE POD** — Provides low to medium altitude offset data coverage. The system consists of a 24-inch focal length KA-108A offset/vertical camera positior ble inflight horizon-to-horizon, and a KA-99 panoramic camera.

**OFFSET HIGH ALTITUDE POD** — Provides high altitude offset, flyover/flyby data coverage. The system consists of two 24-inch focal length cameras, a KA-108A offset/vertical camera (positionable inflight) and a KA-93 panoramic camera providing four fields-of-view plus a 20° sector mode positionable inflight.

**LONG RANGE OBLIQUE POD** — Provides high ground resolution (1.26 feet typical) data during peripheral reconnaissance. The camera is a special purpose 48-inch focal length system positionable inflight from horizon-to-horizon

**SIDE LOOKING RADAR POD** — Provides high resolution radar data gathering information during peripheral reconnaissance at altitudes from 500 feet to 50,000 feet. The side-looking radar is the AN/APD-10 Goodyear System. The total system including the ground processing equipment is designated UPD-4

**LOW TO MEDIUM ALTITUDE DAY/NIGHT POD** — Provides low to medium altitude day/night flyby/flyover data gathering capabilities. The primary system configuration consists of a KA-108 side oblique or vertical camera installation, split vertical 3- or 6-inch focal length KS-87B cameras, a KA-56E panoramic camera and an IR line scanner. An alternate configuration consists of a 12- or 18-inch focal length KS-87B side oblique camera, a KA-95 panoramic camera and an IR line scanner.

**LOW ALTITUDE DAY/NIGHT GENERAL PURPOSE POD** — Provides low altitude day/night flyby/flyover data gathering capabilities. The system configuration provides forward oblique, vertical, side oblique, infrared, and bomb damage assessment (BDA) day reconnaissance capabilities. Removal of the tail cone housing the side oblique and BDA camera, and replacement of the tail cone with an electronic flash allows night vertical photography in either the visible or near infrared spectrum as well as infrared mapping. In addition, photo mosaics of unmapped areas may be acquired with the vertical frame camera

*There are a large number of podded reconnaissance sensor options. Several of these have been tested in prototype form. General Dynamics*

hand console to add a standard size panel containing sensor on-off controls, film remaining, and camera status indicators. In addition, the reconnaissance control panel contains all ancillary equipment controls for the radar altimeter, data annotation set, the reconnaissance data interface unit, manual (backup) insertion of altitude and ground speed for velocity over altitude (V/H) calculations, the percent of film coverage overlap, and camera exposure (cloud cover) controls. Additional reconnaissance status indicators such as velocity over altitude and a pod heat caution light are located for ready visual reference on the right-hand instrument panel.

The F-16B can be utilized to provide reconnaissance capability either through the carriage of missionized pods or in the dedicated RF-16 configuration. The rear cockpit of the F-16B easily accommodates the required reconnaissance controls as well as offers a substantial area for additional future growth. The flight control side-stick and the throttle in the rear cockpit may be retained for the reconnaissance role or those controls can be removed.

General Dynamics has evaluated a large number of reconnaissance sensors and equipments for potential application with the F-16. A variety of photographic cameras and focal lengths, infrared line scanners, and a side-looking radar system have been investigated to evaluate potential application in a reconnaissance role. Other sensor systems are under consideration for additional study and specific customer requests can usually be accommodated.

**Control Configured Vehicle**—The fighter Control Configured Vehicle (CCV) was the product of an advanced development program sponsored by the Air Force Flight Dynamics Laboratory. A modified YF-16 was used to investigate CCV concepts for fighter aircraft. General Dynamics modified the #1 YF-16 prototype (72-1567) to incorporate twin vertical canards (of approximately 8 sq.' area each), a means of isolating port and starboard wing fuel tanks from the forward and aft fuselage fuel cells, provision for a manual means of varying the aircraft c.g. position, modifications to the flight control system to permit the use of wing trailing edge flaperons (flaps/ailerons) in combination with the all-moving stabilator to provide directional lift control, and similarly to use the new canards and the conventional rudder in conjuction to give direct side-force control, and a CCV auxiliary flight control system to permit evaluation of three Direct Lift Control (DLC) modes, three Direct Side Force Control (DSFC) modes, a Maneuver Enhancement/Gust Alleviation mode, and relaxed static stability mode.

The term Control Configured Vehicle expresses the need to design aircraft from the onset to take advantage of the performance benefits available through advanced flight control technology. The fly-by-wire flight and relaxed static stability control system found in the YF-16 made it feasible to go beyond conventional control of an aircraft into an area of specialized and tailored control functions. This area of auxiliary control functions, their definitions and demonstrations, was explored by the CCV program.

The objective of the CCV program was to develop flight control techniques which could improve the performance and mission effectiveness of future fighter aircraft. The approach to meet this objective was to analyze, design, and incorporate into the YF-16 prototype those advanced CCV concepts which demonstrated a measurable performance improvement and had mission impact to both near and far term fighter/attack aircraft.

The potential benefits of CCV included the following:

(1) The ability to increase load factor without increasing angle of attack.
(2) Fuselage pointing for weapon aiming with possible application with an integrated fire/flight control system.
(3) The ability to turn without banking thereby eliminating the pendulum effect of in air-to-ground deliveries with a depressed pipper.
(4) The ability to translate sideways at a constant velocity to compensate for crosswinds during air-to-ground weapons deliveries.
(5) Automatic gust alleviation.
(6) Maneuver enhancement.
(7) The ability to change a velocity vector during air-to-air combat without broadcasting the plane of motion.

The CCV program started in 1973 with initial design studies and planning. The Request For Proposal (RFP) was issued on July 23, 1973. Contract go-ahead was received in December of 1973 and the control system design was completed in March of 1975. The YF-16 prototype was transferred to the program in August of 1975 and modification at General Dynamics' Fort Worth facility was completed in December. The first flight of the modified airplane took place on March 16, 1976 at Edwards AFB, California, with General Dynamics company test pilot Dave Thigpen at the controls.

The flight test program was originally scheduled to run for about eight months and 85 flights. However, on the 29th CCV flight on June 24, 1976, the airplane was seriously damaged during landing when a powerplant failure occurred at a critical time. Repairs consumed just over six months and the airplane was not returned to flightworthy status until the spring of 1977.

The CCV YF-16 program was separated into four distinct phases, as follows:

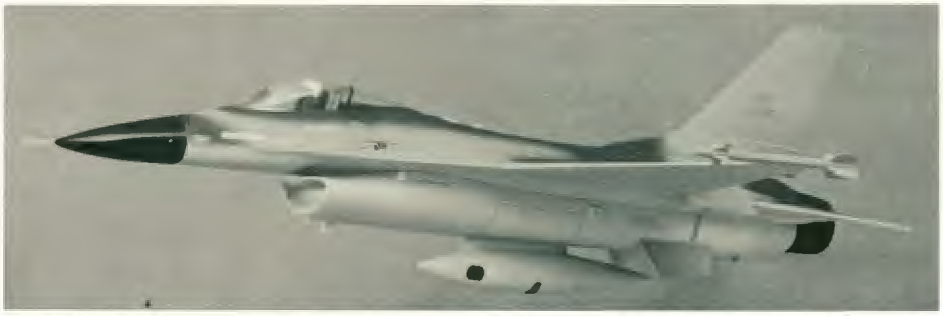
**Phase 1A** . . . **Configuration Selection and Planning**
Select Aerodynamic Configuration
Ground and Flight Test Plans Complete
Class II Mod Doc (Pt.1) Complete
Select LEF/TEF/HT Schedule

**Phase II** . . . . **Detail Design**
Airframe Design Complete
F.C.S. Computer Design Complete
Design Reviews
Structural Flight Envelope Defined
Phase II Final Report Complete

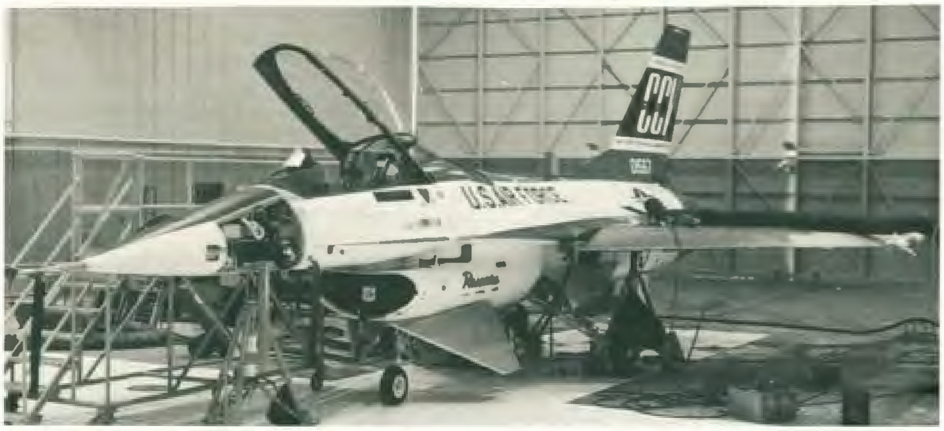
**Phase IB** . . . **Control System Design**
Set. F.C.S. Configuration
Brief AF on Predesign Studies
Phase I Final Report Complete

**Phase III** . . . **Fabrication/Modification**
Parts Fabrication Complete
YF-16 #1 Available for Modification
Start YF-16 #1 Modification
YF-16 #1 Modification Complete
Ground Tests Complete
Class II Mod Doc (Pt.II) Complete
Flight Readiness Inspection
Functional Check Flights Complete

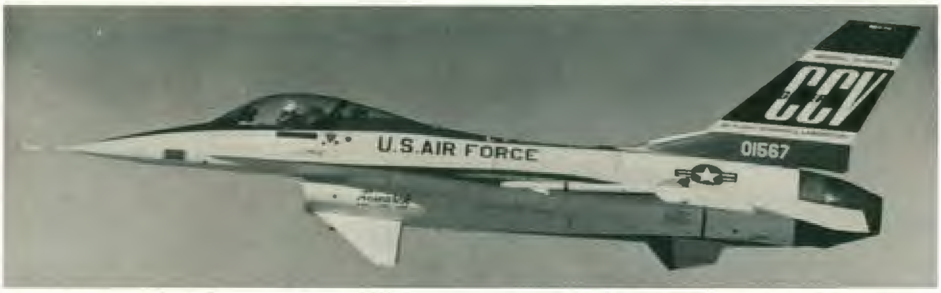
**Phase IV** . . . **Test Phase**
Flight Test Program Complete
Final Report



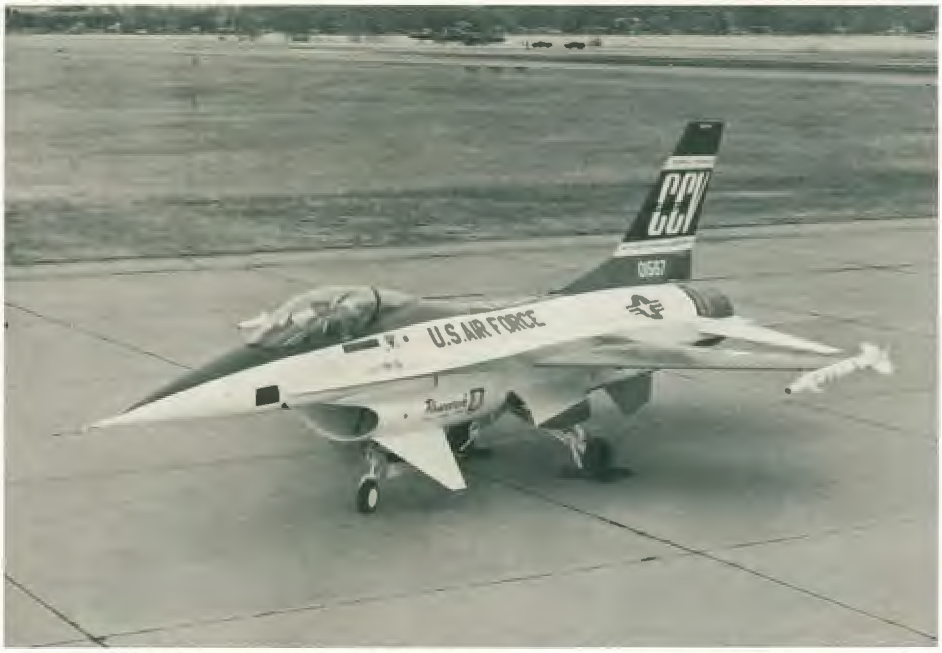
*Model of F-16A illustrates configuration and location of podded version of HIAC long range high-resolution oblique photography camera. Window in pod and barrel of camera rotate from horizon to horizon. General Dynamics*



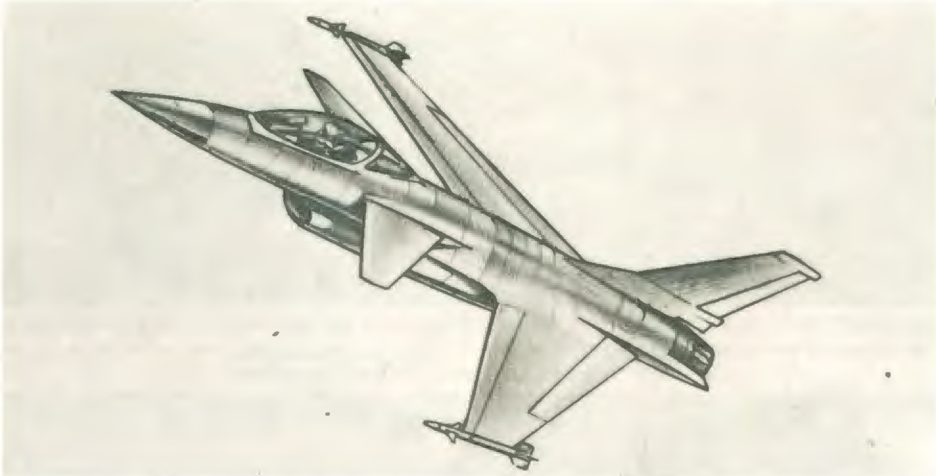
*The YF-16 prototype, 72-1567, is shown at General Dynamics undergoing modification to Control Configured Vehicle (CCV) testbed. General Dynamics*



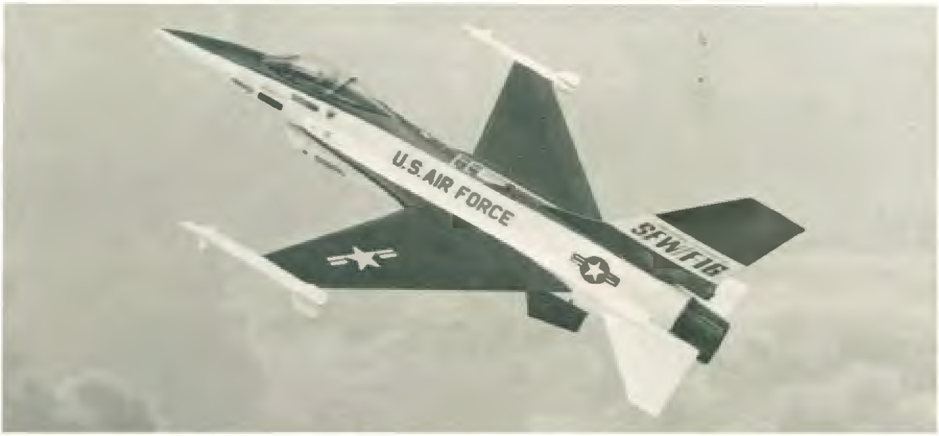
*CCV's large movable canards were the most noticeable external change to original YF-16 prototype. General Dynamics*



*Most of the CCV YF-16 modifications were internal. General Dynamics*



*This early FSW F-16, with forward swept canards, was one of the early studies generated by the company in response to the DARPA request for FSW demonstrator proposals. General Dynamics*



*The final FSW F-16 proposal was a bit more conventional and utilized an FSD F-16A fuselage with a composite construction forward swept wing. General Dynamics*

*Mock-up for a General Dynamics developed laser designator unit of the Pave Tack type. General Dynamics*

*Enlarged nose radome was developed in mock-up form to explore two options: (1) the incorporation of the more powerful APG-65 radar; and (2) the incorporation of the 40" focal length HIAC camera. General Dynamics*

Following a successful flight test program that lasted into July of 1977, the CCV program was terminated and the modified YF-16 was returned to the Air Force for disposition. Static work continued with the airplane into 1979, at which point it was transferred to Wright-Patterson AFB, Ohio, to undergo additional static test work. As of the date of this writing, that work continues.

**Forward Swept Wing**—Until recently, the use of swept-forward wings had generally been ruled out as a design consideration due to the aeroelastic phenomenon known as divergence (Aeroelastic divergence occurs for certain wings when the dynamic pressure is sufficiently large that a change in lift caused by a wing deformation is greater than the structural elastic restoring forces, and the deformation increases until the structural limits are exceeded and the structure fails). With the advent of advanced composite materials, a new capability (material tailoring) was added to structural design and accordingly, engineering teams began reorienting their design priorities.

In 1976, the Defense Advanced Research Project Agency (DARPA) initiated a major program directed at the following goals: (1) verifying the validity of avoiding forward swept wing (FSW) severe weight penalties; (2) defining some of the advantages of the FSW; (3) expanding the FSW technology base; and (4) generally opening the aircraft design space to include FSW candidates.

To achieve these goals, the DARPA, with the assistance and technical advice of the Air Force Flight Dynamics Laboratory (AFFDL), contracted with three aircraft manufacturing companies, General Dynamics, Grumman Aerospace, and Rockwell International, for a series of comprehensive technology efforts. This work was supported by the Virginia Polytechnical Institute and the NASA.

General Dynamics' submission in this program, which eventually resulted in a contract with Grumman to build two examples of their Design 712 (as X-29A's), was a modified prototype YF-16 that retained the stock fuselage and incorporated a totally new composite construction forward swept wing. Other modifications would have included changes to the fly-by-wire flight control system and revised test instrumentation.

When Grumman was declared the winner of the DARPA program competition, the General Dynamics FSW F-16 program was terminated (though some FSW studies are continuing within the company). It is historically significant to note that in the early 1950's General Dynamics won a contract to study forward swept wing technology for application to bomber designs. The end result was the radical XA-44/XB-53, which unfortunately did not progress beyond the full-scale mock-up stage.

**F-16/79**—This modification was produced in response to a Department of Defense authorization calling for the development of an aircraft for sale to export nations in which a first-line U.S. fighter might not be required. General Dynamics responded to this Fighter Experimental (FX) RFP with a modified F-16 design incorporating an older technology J79-GE-119 (formerly the J79-GE-17X) afterburning turbojet engine and a slightly revised intake configuration offering improved pressure recovery for the J79 configuration. The prototyping project was funded in-house by General Dynamics and the modified airplane, the #2 FSD F-16B (75-0752), was flown for the first time from General Dynamics' Fort Worth facility on October 29, 1980. A somewhat abbreviated flight test program followed, officially ending in

January of 1981.

The F-16/79 is considered to be an advanced technology, low-cost fighter designed to provide outstanding intercept capability, excellent performance in the air-to-air combat arena, and equally significant capability for air-to-surface weapons delivery. It is available in two fully combat capable versions: the single seat F-16/79A, and the two seat F-16/79B (the only one of the two to have been prototyped). Both models are identical in size, and all systems are the same. The only difference is in the aft cockpit, added to the F-16/79B, which displaces approximately 1,100 pounds of fuel. Armament consists of up to six AIM-9 infrared heat-seeking missiles, free-falling iron bombs and related weapons, and a single M61A-1 rotary cannon.

Differences between the F-16/79A and the F-16/79B are as follows:

| | F-16/79A | F-16/79B |
|---|---|---|
| Empty Weight | 17,006 lbs. | 17,677 lbs. |
| Internal Fuel | 6,956 lbs. | 5,773 lbs. |
| Takeoff Gross Weight | 25,593 lbs. | 25,056 lbs. |
| Max. Takeoff Gross Wt. | 37,422 lbs. | 37,422 lbs. |
| Design Load Factor | 9 g | 9 g |
| Service Life | 8,000 hours | 8,000 hours |
| Max. Speed | Mach 2+ | Mach 2+ |
| Length | 49'6" | 49'6" |
| Wingspan | 32'10" | 32'10" |
| Height | 16'8 1/2" | 16'8 1/2" |

**F-16/101** — This program called for flight testing of the 26,500 pound thrust General Electric F101-DFE (Derivative Fighter Engine) in the #1 FSD F-16A, 75-0745. The test program was originally scheduled to take approximately five months and was designed to determine the F101's suitability as a powerplant for advanced military aircraft (it had already been flight tested, in a slightly different form, in the Rockwell International B-1A). Approximately 100 flight hours were scheduled for the flight test program, during which engine controls and response, emergency controls, air start capability, acceleration, afterburner operation, and performance in simulated combat, were to be evaluated.

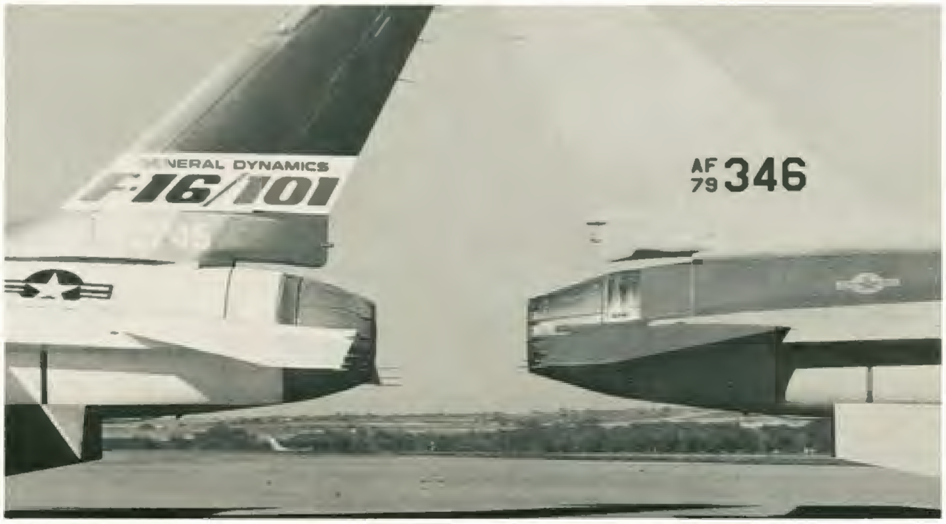
The first flight of the F-16/101 took place at Edwards AFB on December 19, 1980. During test flying it was found that wind-up, or limit-angle-of-attack turns could be accomplished without compressor section stall, and pilots encountered no restrictions on transient throttle control. However, a high-frequency oscillation at the engine inlet occurred because of insufficient air flow at low power settings. This problem was corrected by setting the fuel control on a higher idle lockup.

A nearly disastrous fuel leak encountered during an early test flight occurred when an aluminum fuel-line elbow ruptured on the engine side of the airframe/engine fuel system interface. Company test pilot Dave Palmer skillfully landed the flamed-out F-16 at Edwards without damage to the airplane. Substituting steel for aluminum in the elbow and redesigning the interface structure to alter the orientation of strain loading corrected the problem.

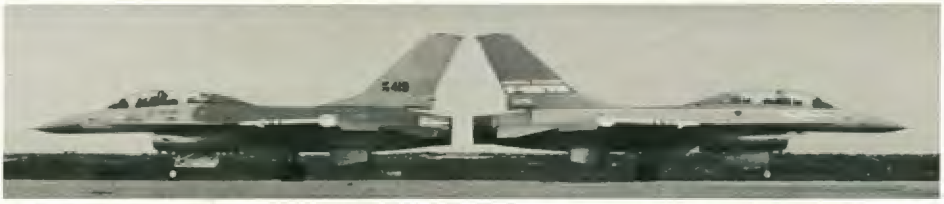
The original flight test schedule had been significantly revised by the time the program ended in July of 1981. The test flights actually completed numbered 58 for a total of some 75 flight hours.

**Advanced Fighter Technology Integration (AFTI)**—In December of 1978, the Air Force selected the F-16 over several competing designs as a testbed with which to explore

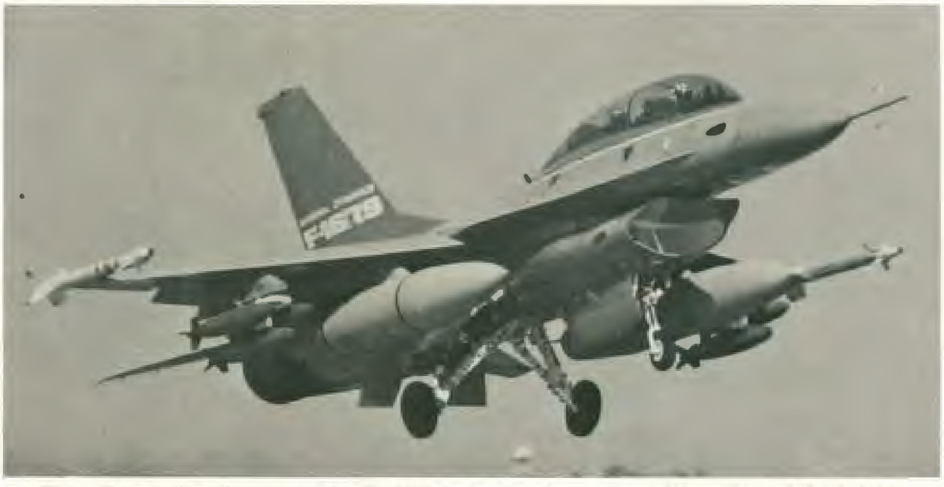
*Performance improvements made possible by the F101 powerplant were tested on the number one FSD F-16A, 75-0745. It is seen at Edwards following an emergency landing caused by a fuel leak. General Dynamics*



*A detailed comparison of the subtle differences between the F101 and F100 engine exhaust nozzles and empennage sections. General Dynamics*



*A detailed comparison of the differences between the J79 and F100 engine exhaust nozzles and empennage sections. General Dynamics*



*The other major change to the F-16/79 is in the size and configuration of the intake. Prototype F-16/79 takes off on a test flight with six Mk.82 bombs and two Sidewinders attached to its wing pylons and launch rails, respectively. General Dynamics* promising new fighter aircraft technologies as part of the AFSC's Flight Dynamics Laboratory's AFTI program. General Dynamics was awarded a $34,300,000 prime contract, under which it was asked to modify the #7 FSD F-16A, 75-0750 to the AFTI configuration. The airplane was flown to General Dynamics to undertake the modification effort on March 6, 1980.

The basic objective of the complex AFTI program, which is being co-sponsored by the Navy and the NASA, is to explore ways of increasing aircraft survivability and attack efficiency in combat. This will be explored by greatly improving the AFTI F-16's maneuvering ability and weapons delivery systems through advanced aerodynamic and computer technology.

AFTI F-16 systems developments include triplex-digital fly-by-wire flight controls, advanced displays, system management computers and integrated flight and weapons fire controls. External and aerodynamic changes include an enlarged dorsal avionics bay and the intake mounting of movable canard surfaces for direct force control. Dimensionally, the AFTI F-16 remains unchanged from a standard F-16A.

**Wild Weasel**—On April 7, 1978, General Dynamics announced that the company was involved in the development of a "Wild Weasel" defense suppression version of the F-16B. No Air Force requirement for the airplane existed at the time, but foreign interest was said to be sufficient to merit exploration of the concept by the company.

Included in the studies were versions to provide electronic countermeasures support for other strike aircraft or to act independently in the dual hunter-killer role. One less-sophisticated version utilized the F-16's stock Loral ALR-46 radar homing and warning receiver to cue defense suppression weapons.

In the Wild Weasel role, the F-16B aerodynamic testbed (modified from the #1 FSD F-16B, 75-0751) mounted antenna pods on each wingtip for enemy ground radar emission detection and an ALQ-131 electronic countermeasures pod on the fuselage centerline store pylon. Weapon options included Texas Instruments AGM-45 *Shrike* missiles, General Dynamics/Pomona AGM-78F Standard ARM antiradar missiles, Texas Instruments AGM-88 *Harm* antiradar missiles, and the Hughes AGM-65 *Maverick*. These could be mounted on any one of the outboard four wing pylons.

Little information relating to the internal radiation sensing equipment and its associated back seat instrumentation has surfaced, but it is assumed that the baseline sensors were similar in most respects to those installed in the Republic F-105G Wild Weasel modification utilized so effectively in Viet Nam.

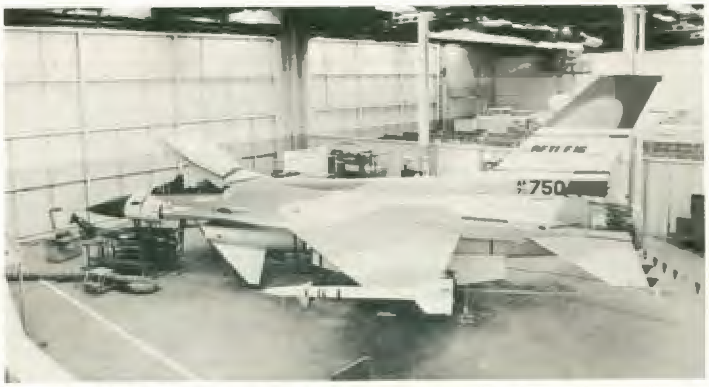
**Miscellaneous**—There have been numerous minor design studies conducted during the course of the F-16 program, some of which have resulted in actual hardware and others of which never progressed beyond the drawing board. One of the latter was conducted by the NASA at their Langley Research Center facility. In August of 1975, it was unveiled that NASA had studied the possibility of utilizing the F-16's (and, at the time, the F-17's) high thrust-to-weight ratio for purposes of VTOL flight. Bleed air thrusters for control (roll thrusters in the wingtips and pitch and yaw thrusters in the tail) of the vehicle in hovering flight were provided on the wind tunnel models utilized, as was a pivoted nose/cockpit section (allowing the pilot to remain in a conventional horizontal attitude while the airplane hovered in vertical attitude).

The tests were conducted in the NASA Langley 30' x 60' full-scale tunnel, and it was proven that the concept was feasible. The tests lasted approximately two weeks.

Perhaps the most recent modification activity to be undertaken in the F-16 program is that of "stealthizing" the airplane. The objective has been to lower its already minimal radar signature through the use of new, low reflectivity materials and some surface configuration revision. The latter, for obvious aerodynamic reasons, can not be too extensive, but the former has involved extensive study and some prototype test work. Primary efforts have centered around changes in intake configuration and materials with heavy emphasis being placed on composite external surfaces and internal structural design. Understandably, this area remains technologically sensitive and little information has been released for public dissemination.

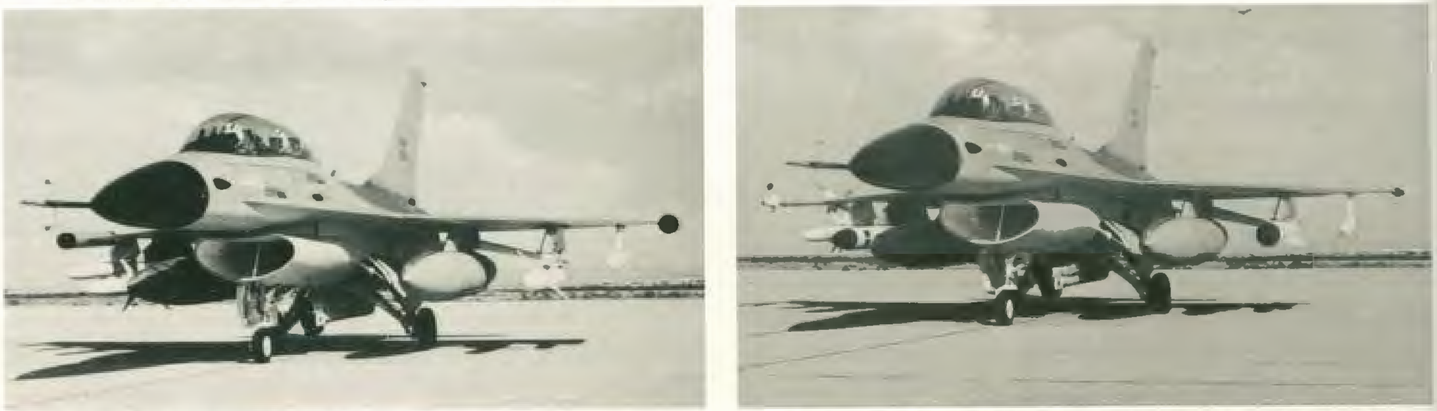
Perhaps the least known of the many test programs that have been conducted utilizing the F-16 is the Air Force Flight Dynamics Laboratory's jointed, hard plastic shell tire shells which are designed to lighten the landing gear imprint on soft and rough surfaces by as much as 65%. Called Flotrak, the idea was tested in September of 1981 on the #1 YF-16, and earlier on an operational F-16A. The system was tested by towing the airplanes over grass, random debris, and pavement. The tire footprint, which is normally 275 psi, dropped to 80 psi when the Flotrak device was used.

Flotrak was made of a polyester elastomeric material that is high-temperature resistant. The system was designed and fabricated by Vehicle Systems Development Corporation, Upland, California and molded by Stevens, Inc., East Hampton, Mass.

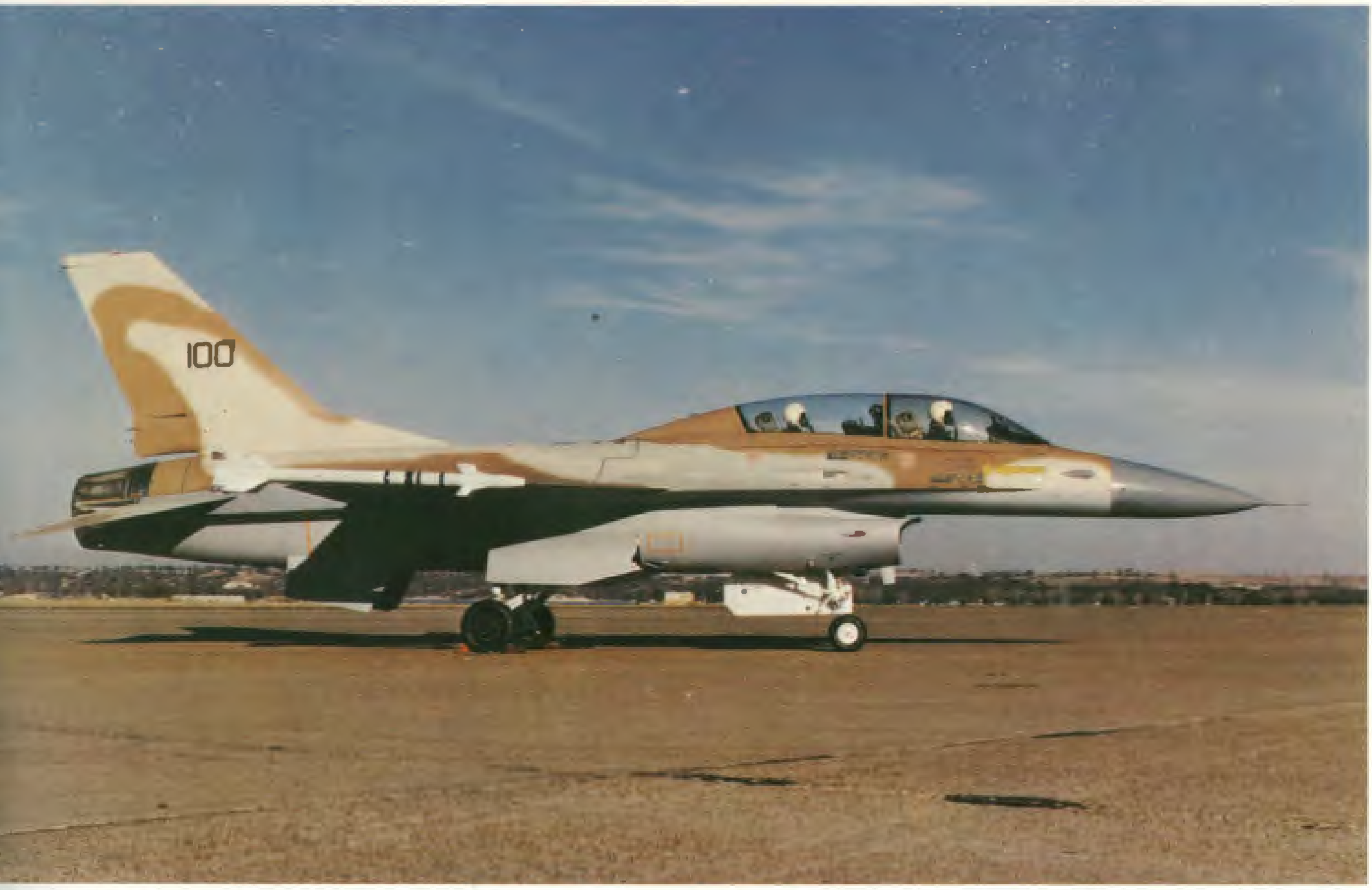


*The AFTI F-16A is due for roll out and first flight at any time. Airplane sports unusual light grey on medium grey camouflage. Canards are same canards used on CCV airplane. General Dynamics*

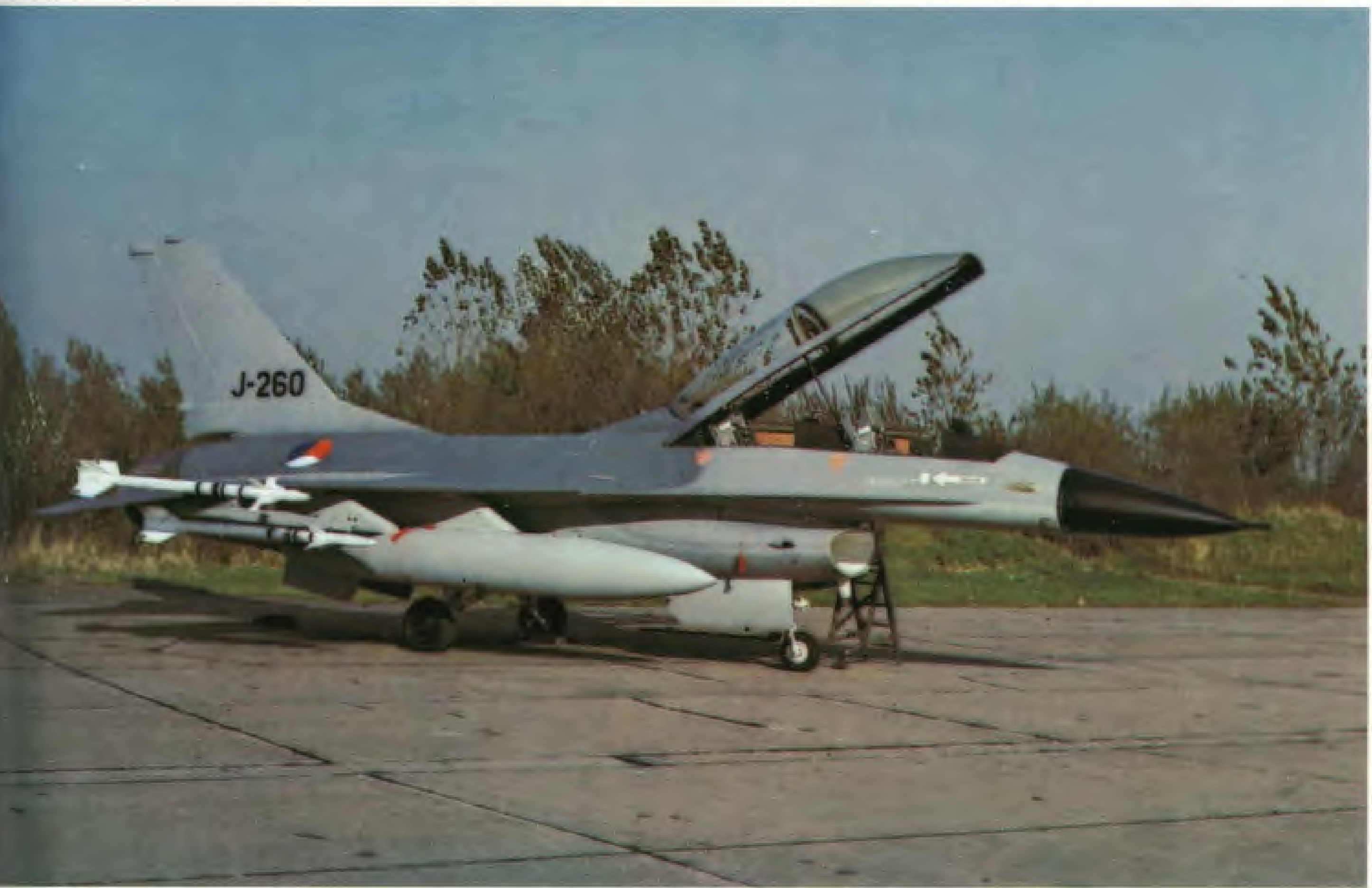
*Full burner takeoff of F-16/79 from General Dynamics Fort Worth facility. General Dynamics*



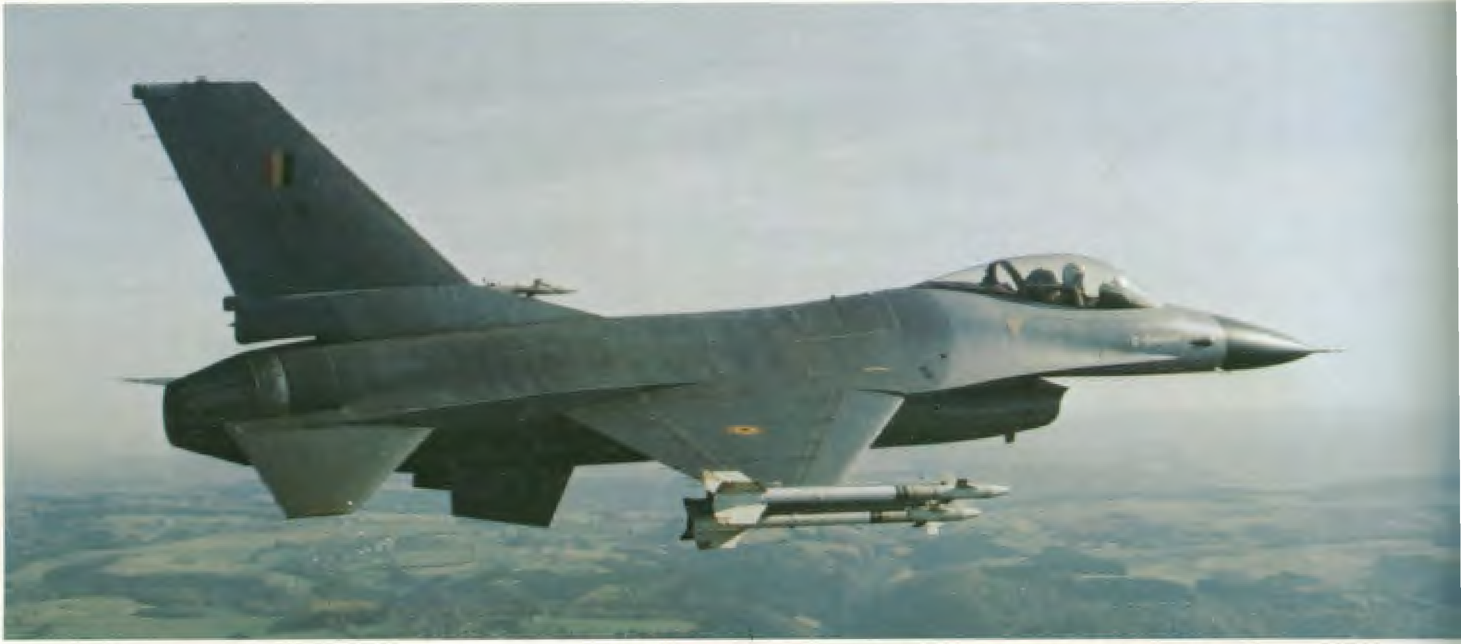
*First FSD F-16B, 75-0751, was mocked-up by General Dynamics to explore the potential use of the F-16 in the Wild Weasel anti-radiation role. Two views show the airplane with various weapon loads including Shrike, HARM, and Sidewinder. Photo on left shows airplane with wingtip sensor pods. General Dynamics*



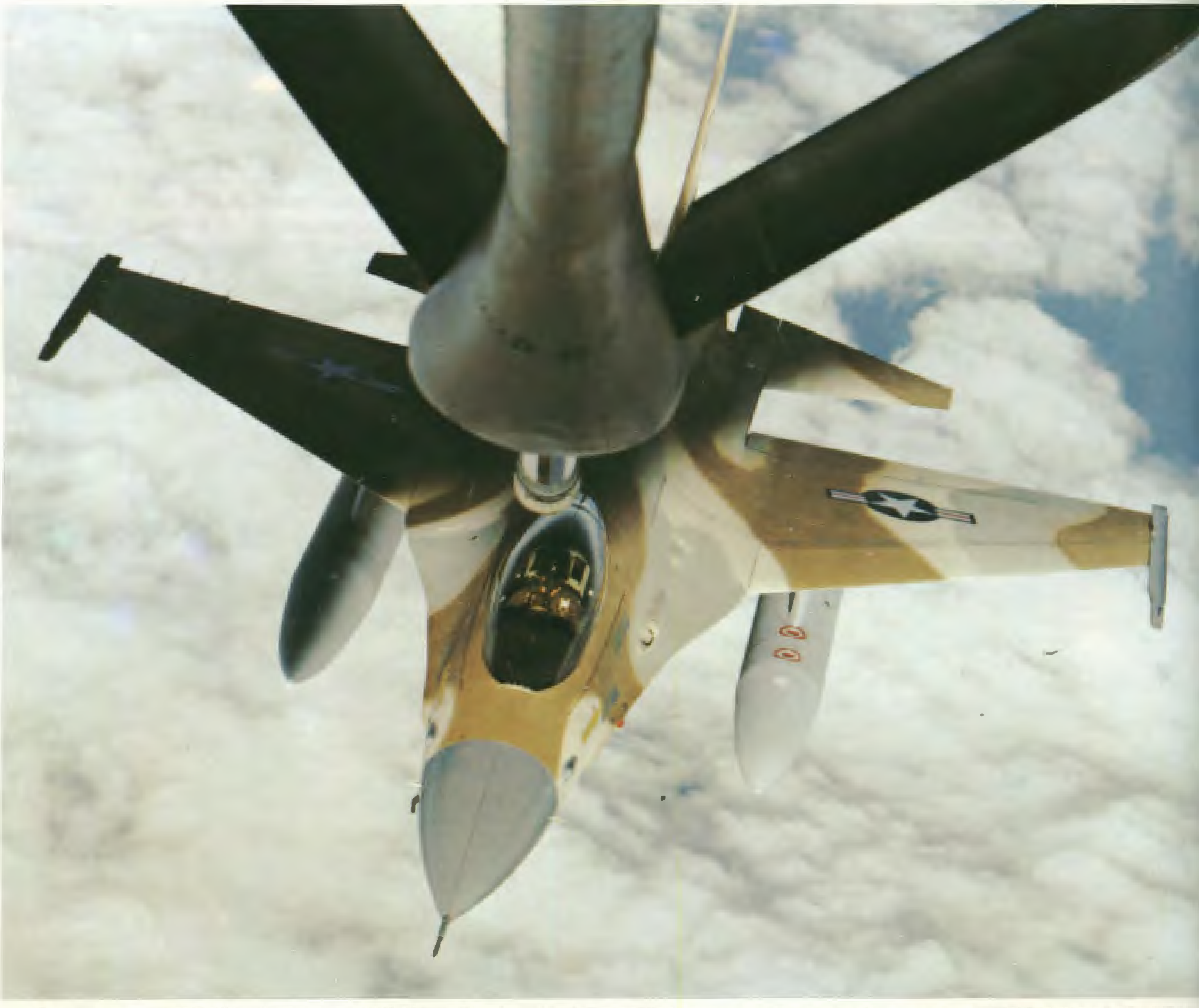
First Israeli Air Force F-16 was F-16B, 100, which was the 103rd production aircraft and which was allocated USAF serial number 78-0355. General Dynamics



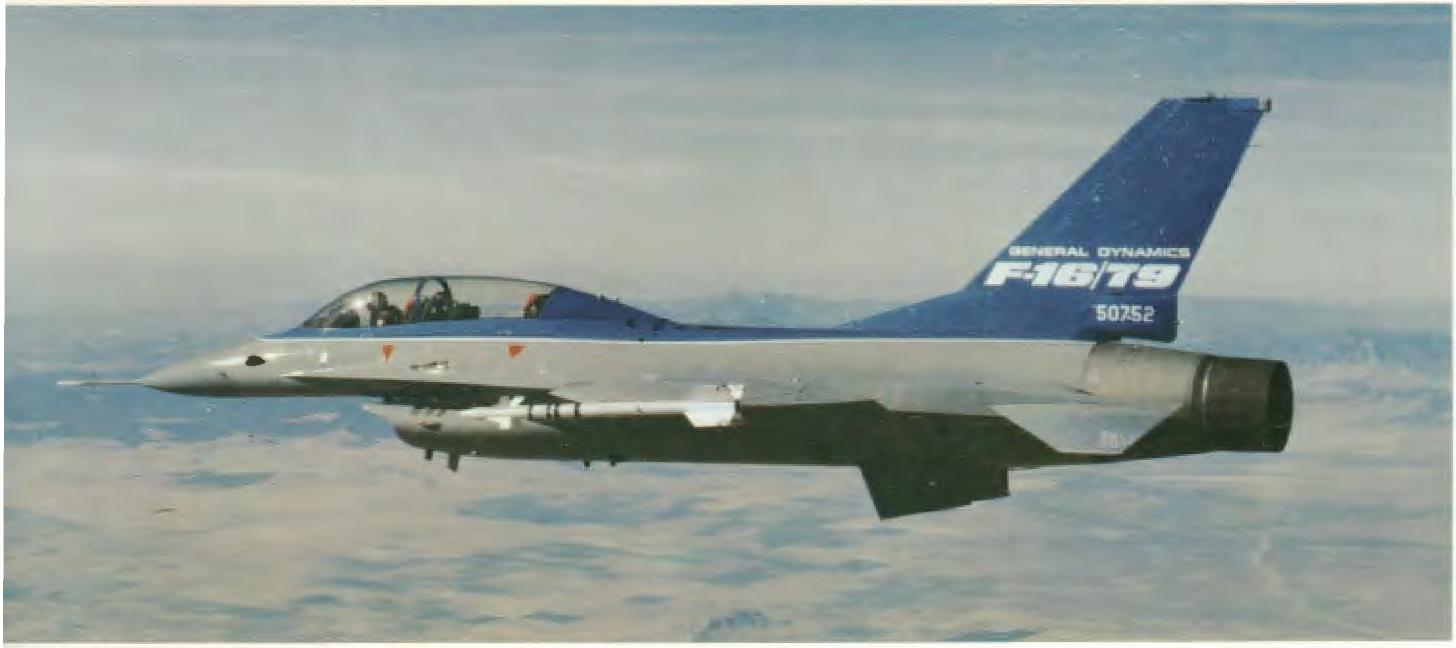
Royal Netherlands Air Force F-16B, J-260, was the 57th production aircraft and was allocated USAF serial number 78-0260. Jack Poelstra via Chris Pocock



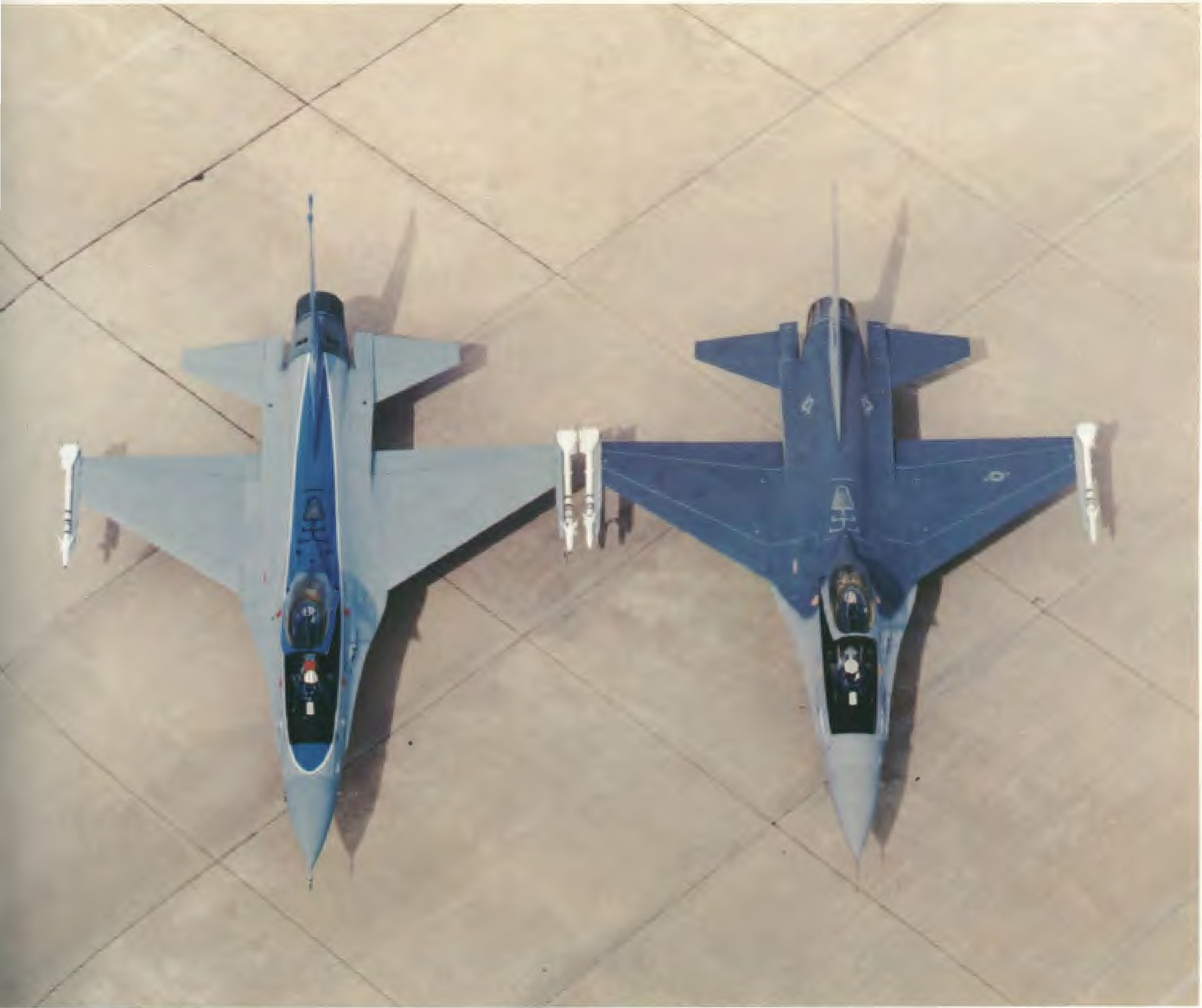
*Belgian Air Force F-16A, FA-14, was the 106th production aircraft and was allocated USAF serial number 78-0129. General Dynamics*



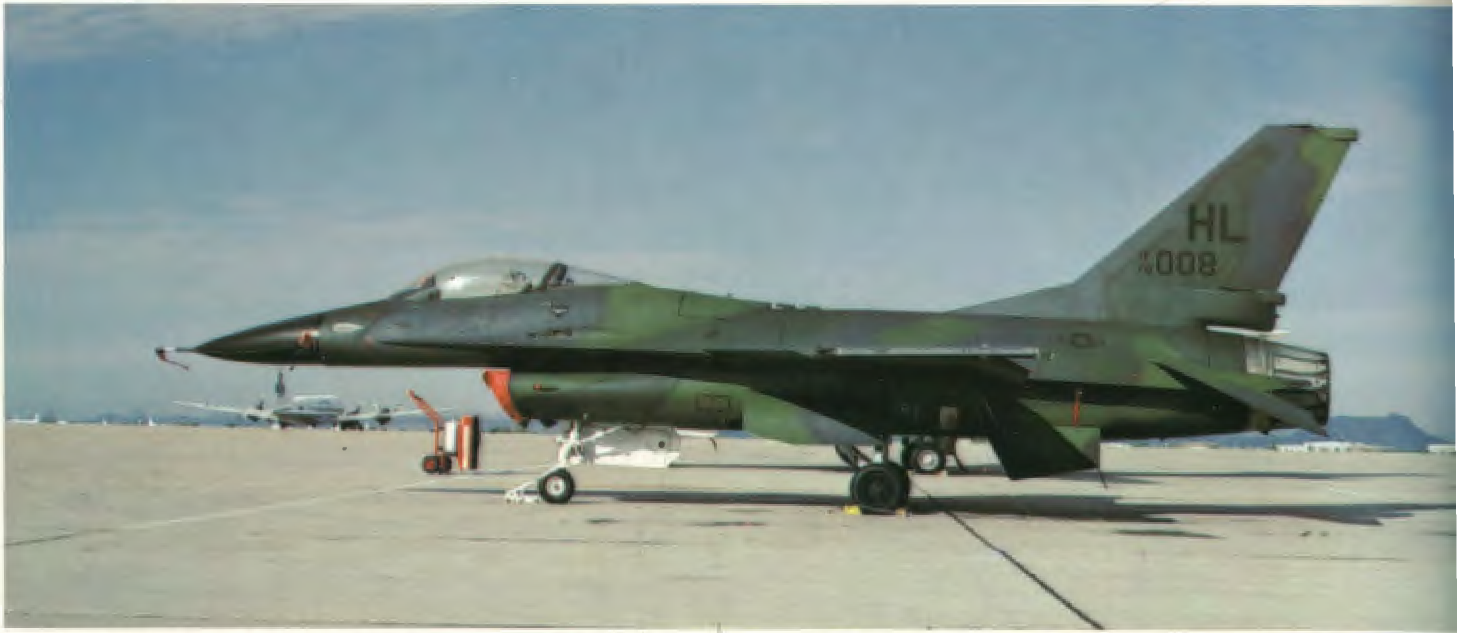
*Somewhere over the Atlantic, an Israeli Air Force F-16A on its delivery flight, moves in for a refueling session at the boom end of a USAF KC-135A. General Dynamics*



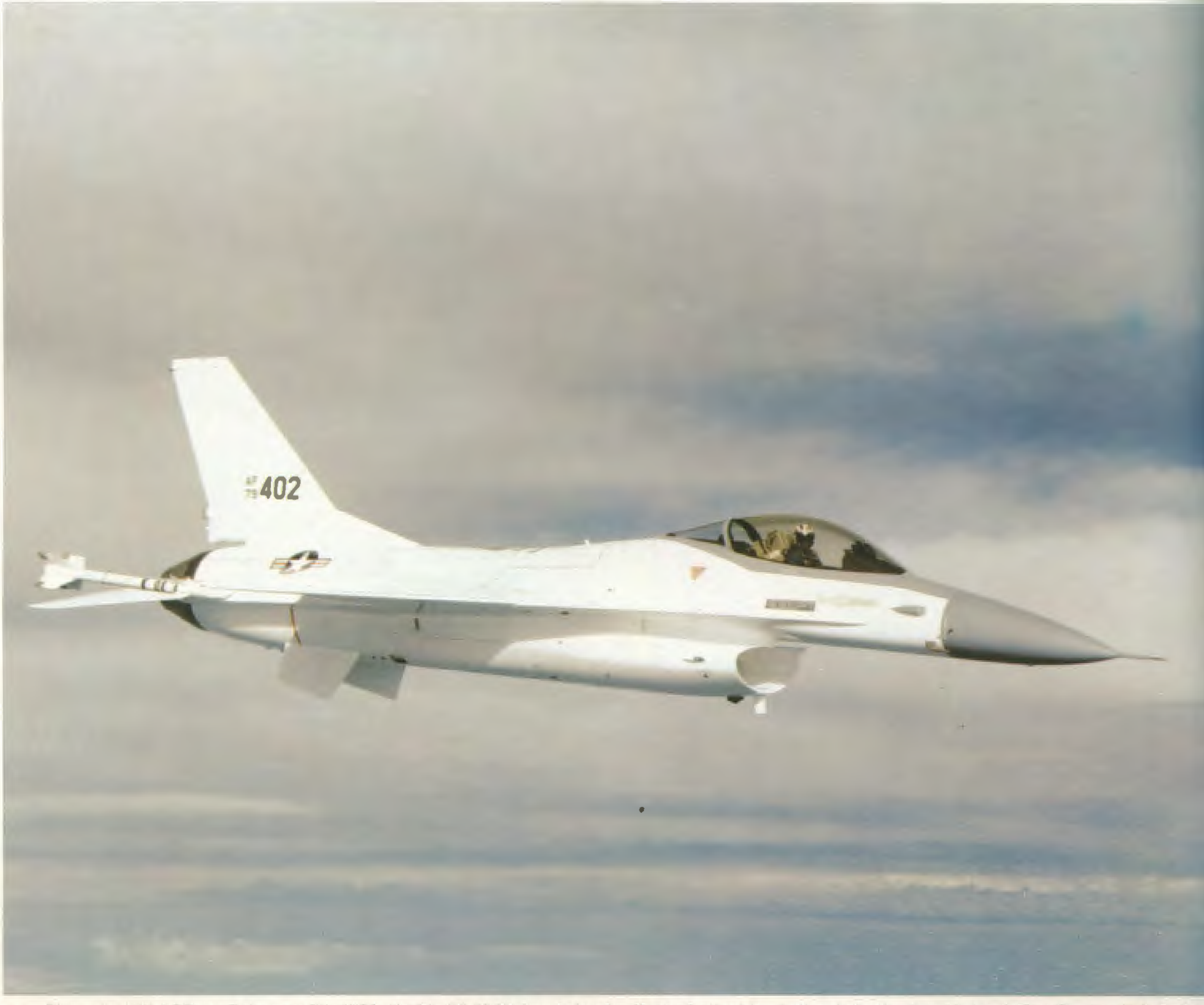
*F-16/79 was modified from the 8th and final FSD F-16, F-16B 75-0752. Revised intake and exhaust nozzle are apparent. General Dynamics*



*F-16/79 poses for photographers on General Dynamics ramp alongside a stock FSD F-16B. Note F-16/79 extended exhaust nozzle for J79. General Dynamics*



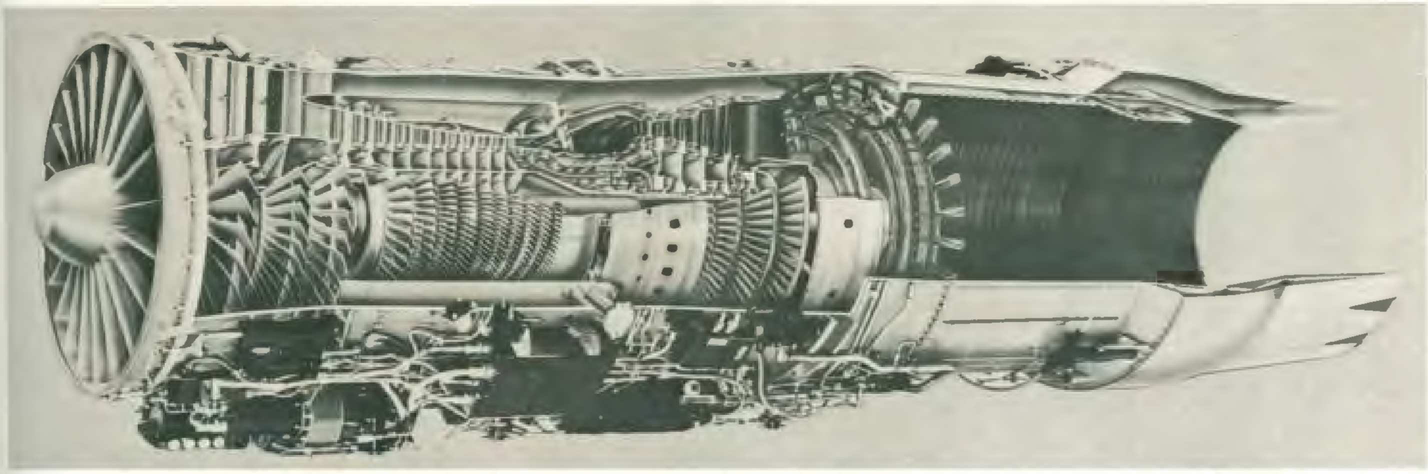
Two F-16's, an "A" and a "B" were experimentally camouflaged during trials at Hill AFB in 1979/80. F-16A, 78-0008, the 30th production aircraft, is shown. Brian Rogers via Jim Goodall



Flown to Hill AFB on February 26, 1982, F-16A, 79-0042, has joined a fleet of all-white F-4's of the Ogden Air Logistics Center. It is to be used to evaluate F-16 modifications and improvements. It is equipped with 267 different critical sensors and pickup points including special wiring to a central location for easy data retrieval. General Dynamics

# CHAPTER 13

# THE PRATT & WHITNEY F100



*Cutaway of Pratt & Whitney F100-PW-200 afterburning turbofan engine illustrates major components. Pratt & Whitney*

Known in-house at Pratt & Whitney as the JTF22, the F100 two-shaft high-augmentation afterburning turbofan is rapidly becoming one of the most important powerplants in the Air Force inventory. Primary propulsion for the McDonnell Douglas F-15 and the General Dynamics F-16, it is a state-of-the-art powerplant with a rapidly improving mean time between failure (MTBF) record and a rapidly increasing time between overhaul (TBO) standard (currently averaging 1,350 hours). The engine design is based on the modular concept in which functionally and physically associated parts are removable as units for improved maintainability.

The F100 can trace its origins back to the JTF16 demonstrator engine of the 1965-1966 period. Air Force funding for an F100 demonstrator was provided not long afterwards and in February of 1970, the JTF22 core was utilized to create the first F100-PW-100 (JTF22A-25A). This powerplant eventually entered production in order to fulfill the requirements of the F-15 program.

In 1971 the F100 was chosen as the powerplant for the General Dynamics Model 401/YF-16. In a slightly different form than that installed in the F-15, this engine, as the F100-PW-200, incorporating a backup fuel control system, revised control-system cooling, and a forward extension of the compressor inlet, entered production as the F-16A powerplant.

Some 3,000 hours of development testing were accomplished between 1968 and the 60 hour preliminary flight rating test (PFRT) in February of 1972. The 150 hour qualification test (QT) was completed in October of 1973.

By January of 1981, F100 running time had exceeded 1,200,000 hours of which approximately 40,000 had been logged by the F-16. More than 1,900 engines had been delivered by that date and production was averaging approximately 40 units per month.

F100 specifications include the following:

*Intake:* Direct pitot type. Fabricated titanium, with fixed nose bullet. Single row of 21 inlet guide vanes, with hot-air anti-iced leading edges and variable-camber trailing-edge flaps.

*Fan:* Three stages. Fan blades have part-span shrouds. Discs of titanium 6-2-4-6, blades titanium 8-1-1. Entry diameter is 36.5 inches. Bypass ratio is 0.7.

*Compressor:* Ten-stage axial, on HP shaft. First three stages have variable stators. Discs 1-2, forged titanium 6-2-4-6; 3, forged titanium 8-1-1; 4, forged Pratt & Whitney Aircraft 1016; 5, 7 and 9, Pratt & Whitney Aircraft 1027; 6, 8, and 10, Gatorized (isothermal squeeze forging) IN-100. Blades 1-3, titanium 8-1-1; 4 titanium 6-2-4-6; 5-9 Incoloy 901; 10 Pratt & Whitney Aircraft 1005. Pressure ratio 8:1. Overall engine pressure ratio 25:1.

*Combustion Chamber:* Annular; designed for smokeless operation. Fabricated in nickel alloy with film cooling throughout. Large-diameter air-blast fuel nozzles. Continuous capacitor-discharge ignition.

*High Pressure Turbine:* Two stages. Discs forged Inconel-100. Blades and vanes Pratt & Whitney Aircraft 1422 directionally solidified alloy with Pratt & Whitney Aircraft 73 coating; first rotor impingement cooled, second with convective (HP bleed air) only. Maximum gas temperature 1,399-degrees C. Maximum speed 13,450 rpm.

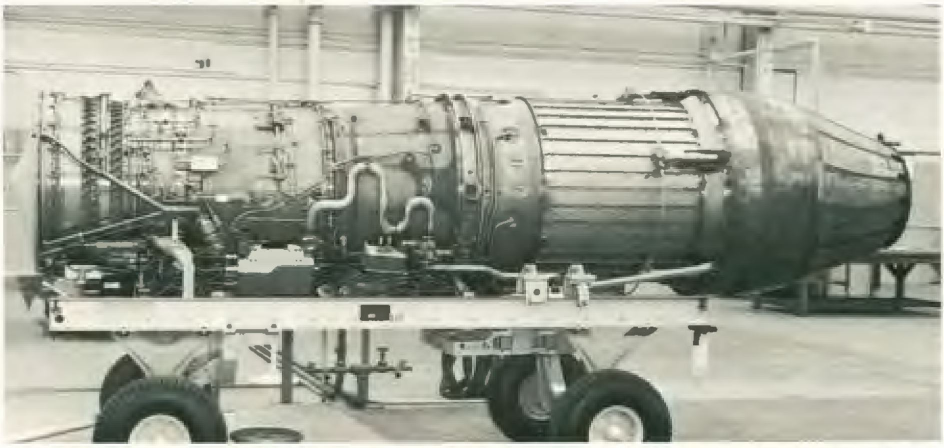
*Low Pressure Turbine:* Two stages. Discs forged Inconel-100 with Pratt & Whitney Aircraft 73 coating. Maximum speed 10,400 rpm.

*Afterburner:* Five concentric spray rings in flow from core engine; two slightly farther downstream in bypass airflow. Flameholder assembly downstream of spray nozzles, with high-energy electrical ignition to give modulated light-up. Outer bypass duct and other major portions fabricated in sheet and stringer titanium. Interior liner of coated refractory material.

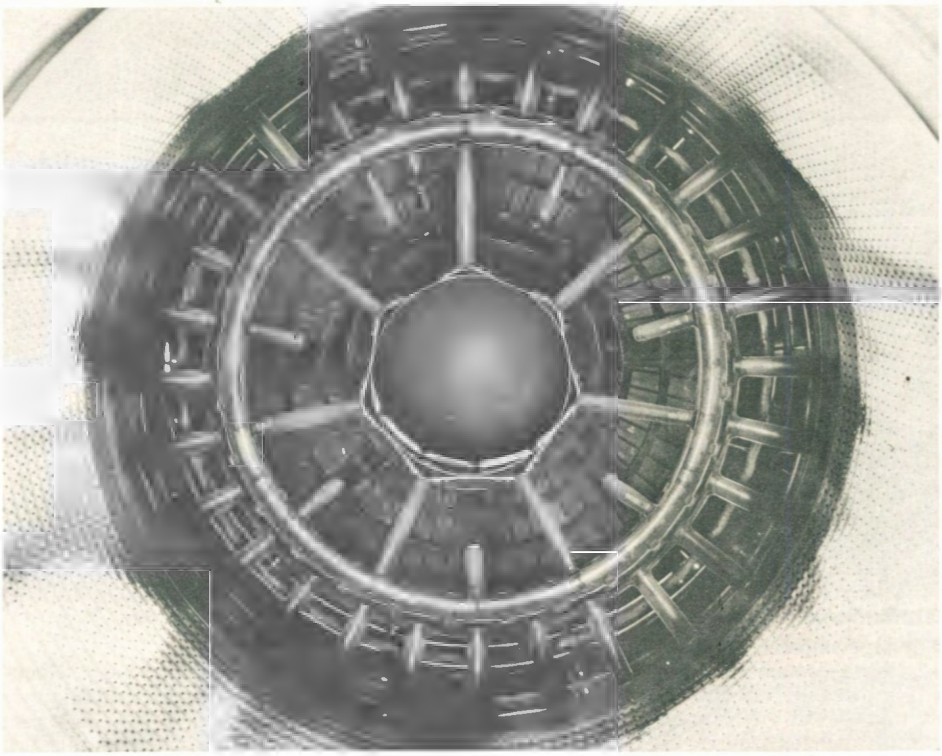
*Nozzle:* Multi-flap balanced-beam articulated convergent/divergent nozzle giving very wide range in area and profile. The convergent nozzle is controlled by the convergent exhaust nozzle control and positioned by a bleed air motor, while the divergent section is allowed to float freely within a narrow range scheduled in conjunction with the primary nozzle.

*Control System:* Unified hydromechanical fuel and nozzle-area control, with electronic supervisory control. The F100-PW-200 also has a hydromechanical backup control.

*Engine Gearbox:* Manufactured by Sundstrand and mounted on the bottom of the engine and driven by a shaft from the high-pressure rotor. The gearbox drives the main fuel pump, the oil pump assembly (which includes pressure oil pumps and scavenge pumps), the engine alternator, and the power takeoff (PTO) shaft, which delivers power to the airframe-mounted gearbox. Fuel is supplied by the engine gearbox-mounted main fuel pump. Bleed air is extracted from 7th and 13th stage ports. The 13th stage air is also supplied to the nacelle ventilation ejectors and the emergency power unit (EPU). Compressor 7th-stage air bleed is used for anti-icing the engine inlet guide vanes and the engine nose cone. During engine starting, bleed air from the 7th-stage compressor is vented into the fan duct to facilitate starting.



*Prototype YF-16's were powered by slightly modified early production F100-PW-100's. Powerplant used in number one prototype is illustrated. General Dynamics*



*Afterburner spray rings and flame holder are located in front of convergent/divergent exhaust nozzle. George Cockle*

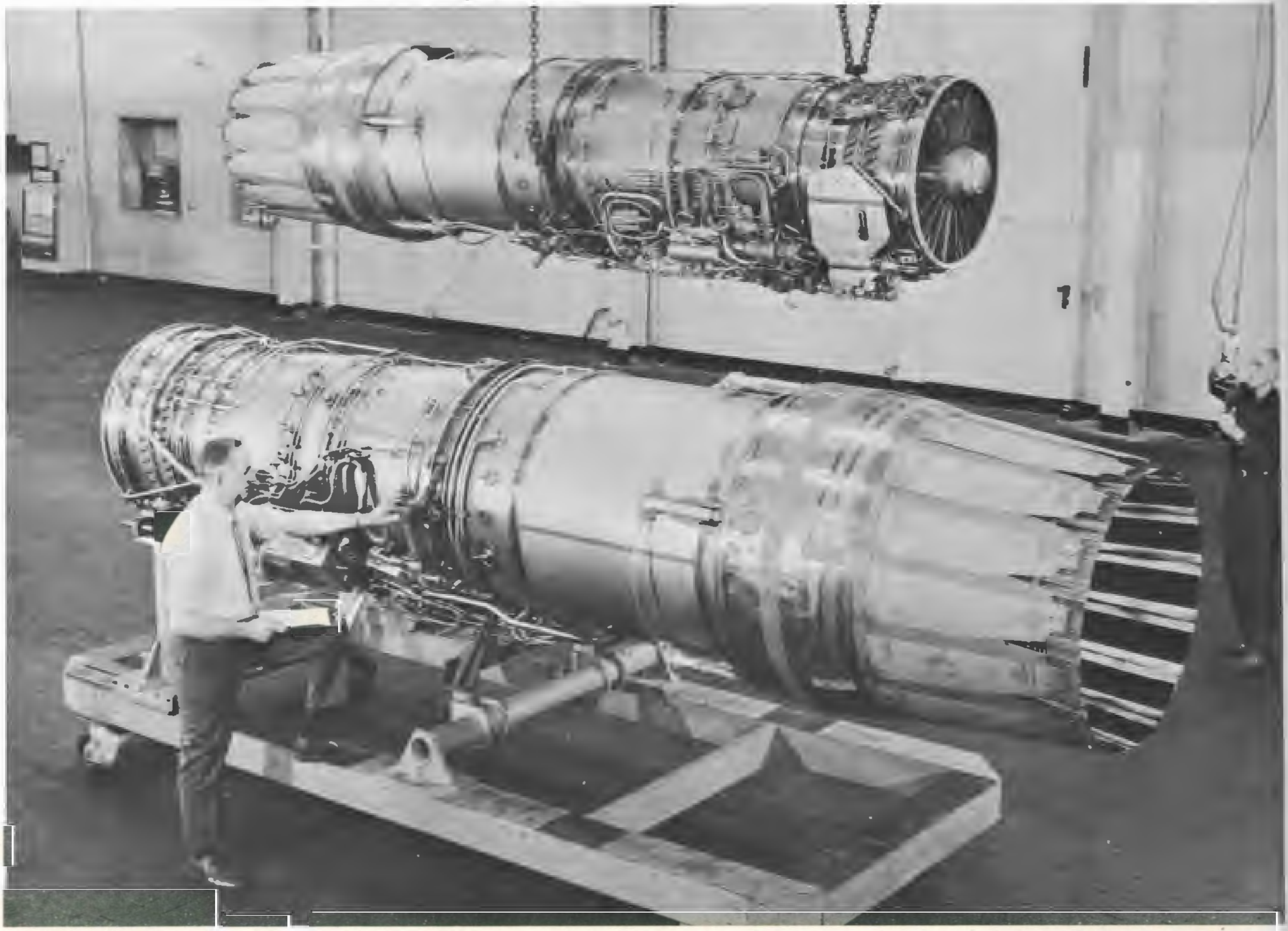
*Engine Anti-Ice:* The anti-ice system routes heated air from the compressor 7th stage to and through the fixed inlet guide vanes and the nose cone.

*Engine Lubrication System:* The engine uses a self-contained hot tank, dry sump-type lubrication system. It consists of an oil tank, main pressure pump, main oil filter, three coolers (using fan duct air, afterburner fuel, and engine fuel), a boost pump, and scavenge pumps.

*Dimensions:*
Overall diameter ........................ 46.5"
Length, excluding bullet ................ 191"

*Weight:*
3,085 pounds (F100-PW-200)

*Performance Ratings:*
Maximum takeoff thrust, dry . . . 15,000+ pounds
Maximum takeoff thrust,
afterburner ................ 23,840+ pounds



*Two views of standard production F100-PW-200 shows full afterburner section. In photo, afterburner makes up approximately half of the engine. Pratt & Whitney*

# CHAPTER 14

# F-16A TECHNICAL DESCRIPTION

The F-16A is a single-engine, single-seat, multirole tactical fighter with full air-to-air and air-to-surface combat capabilities. The airplane is powered by a single Pratt & Whitney F100-PW-200 afterburning turbofan engine. An airframe-mounted accessory drive gearbox powers aircraft accessories. A jet fuel starter (JFS) provides self-starting of the engine.

*Fuselage*—The fuselage is characterized by a large bubble canopy, forebody strakes, and an under fuselage engine air inlet. It is a semi-monocoque all-metal structure of frames and longerons, built in three main modules: forward (to just aft of the cockpit), center, and aft. The nose radome is built by the Brunswick Corporation.

*Wing and Tail Surfaces*—The cantilever mid-wing and tail surfaces are thin and feature moderate aft sweep. The blended wing, of NACA 64A-204 section, has a 40-degree leading edge sweep and leading edge flaps which are deflected automatically to enhance performance over a wide speed range. Wing structure is primarily aluminum alloy and consists of 11 spars, 5 ribs, and single upper and lower skins. Fuselage attachment is by machined aluminum fittings.

The leading edge flaps, of one-piece bonded aluminum honeycomb sandwich construction, consist of a spanwise flap on each wing leading edge controlled as a function of Mach number, angle-of-attack, and altitude by command signals from the electronic component assembly. An asymmetric sensing and braking mechanism prevents flap asymmetry. Actuation is by a drive system using rotary actuators.

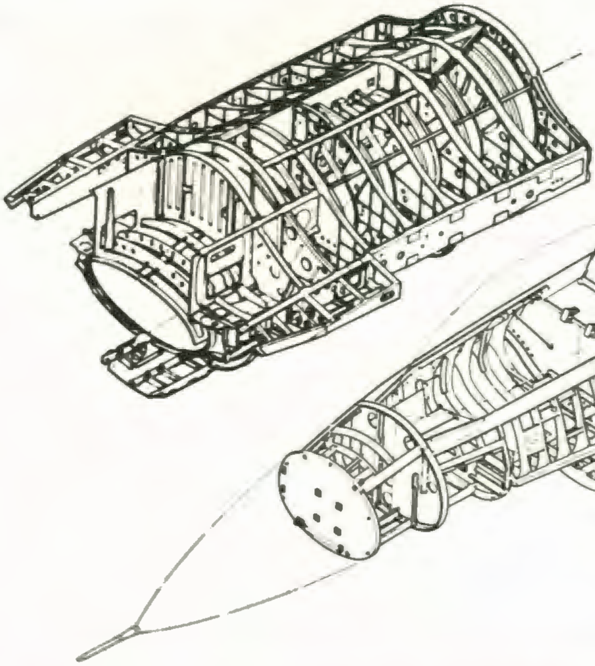
Flaperons are mounted on the trailing edge of the wing and combine the functions of flaps and ailerons. The flaperons have a maximum command deflection of 20-degrees down and 23-degrees up at a rate of 80-degrees per second. When acting as flaps, the deflection is downward; when acting as ailerons, the deflection is up or down as commanded. The trailing edge flaps are controlled as a function of the landing gear handle position. Actuation is by National Water Lift integrated servo-actuators.

The vertical tail, augmented by bonded aluminum honeycomb core, aluminum skin twin ventral fins, provides directional stability. The vertical fin is a multi-spar multi-rib aluminum structure with graphite-epoxy skins, an aluminum tip, and a glassfiber dorsal fin and root fairing.

The interchangeable horizontal stabilizers, of graphite-epoxy composite laminate skins mechanically attached to a corrugated aluminum substructure have a small amount of anhedral and provide pitch and roll control through symmetrical/differential deflection. Each tailplane half has an aluminum pivot shaft, and a removable full-depth bonded honeycomb leading edge. The rudder and stabilator servo-actuators are manufactured by National Water Lift.

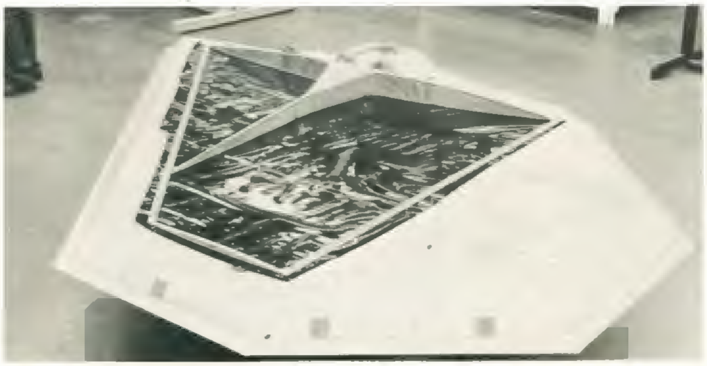
*Landing Gear*—The Menasco-built landing gear system is operated by hydraulic system B in the normal mode. The nose landing gear, equipped with a Goodrich 18 x 5.5-8 tire and located aft of the intake for improved (powerplant) foreign object damage control, is extended and retracted by hydraulic pressure.

The nose gear retracts aft with a 90-degree mechanical wheel twist into the wheel well. For towing purposes, a quick disconnect at the

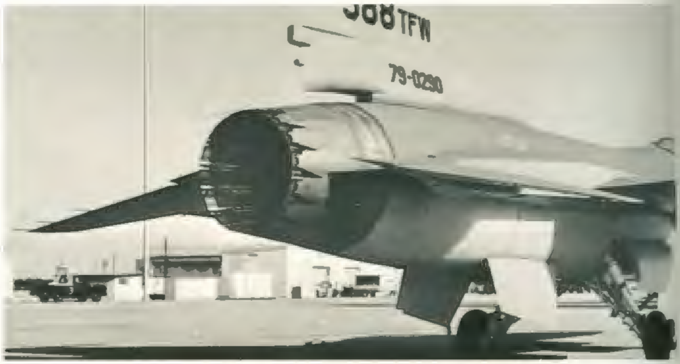


*Forward fuselage major component drawings detail airframe and blended body construction. General Dynamics*

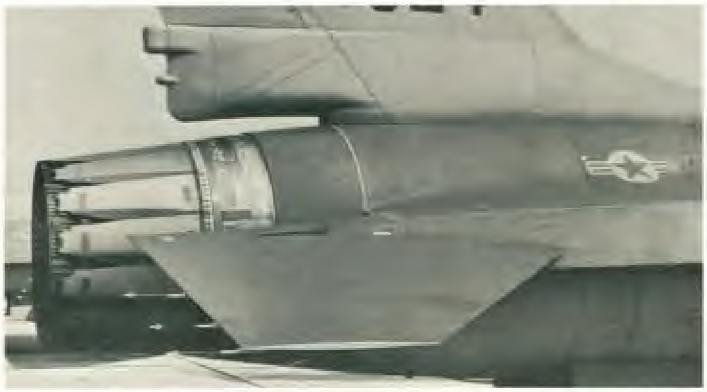
*Powerplant compartment of F-16 has heat reflecting liner. Note intake tunnel. General Dynamics*



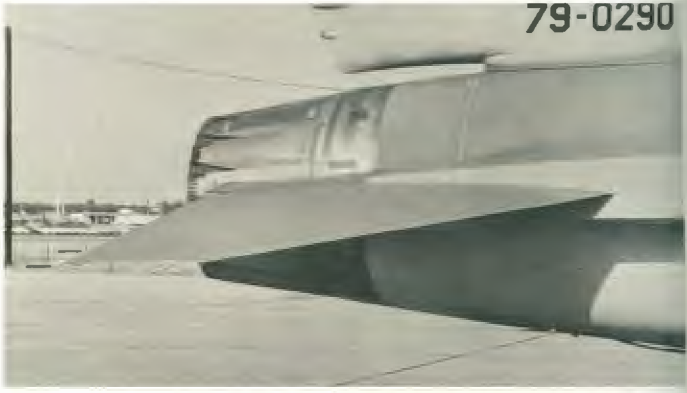
Composite construction utilized in horizontal tail surface requires unusual production techniques. Basic frame is shown prior to addition of composite materials. New stabilator, not shown, has simpler, less expensive construction materials. General Dynamics



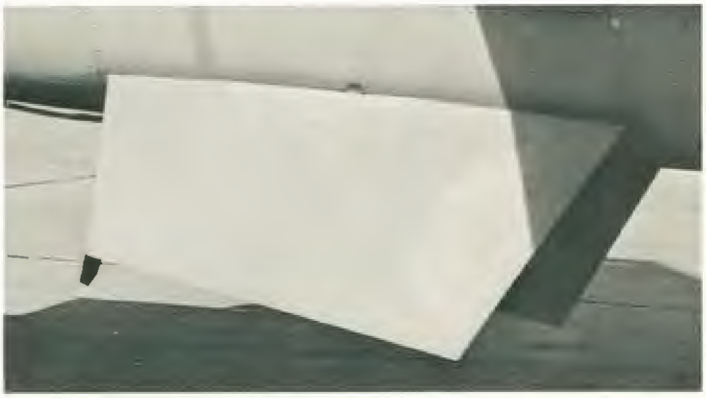
Empennage section details include engine exhaust nozzle, vertical fin fairing, and horizontal stabilators. Aerofax



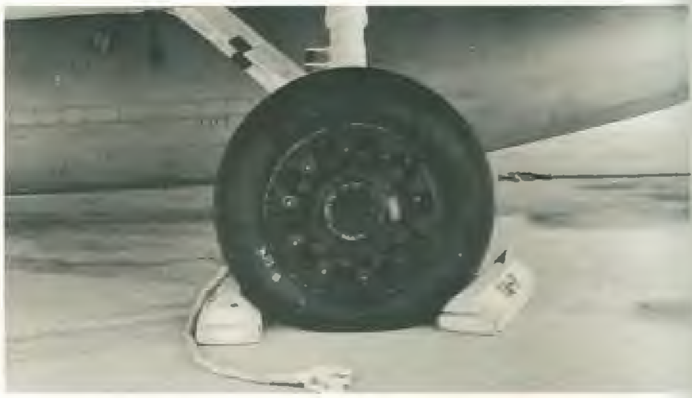
Horizontal stabilators are single piece, all-moving units. Note static dischargers on trailing edge. Aerofax



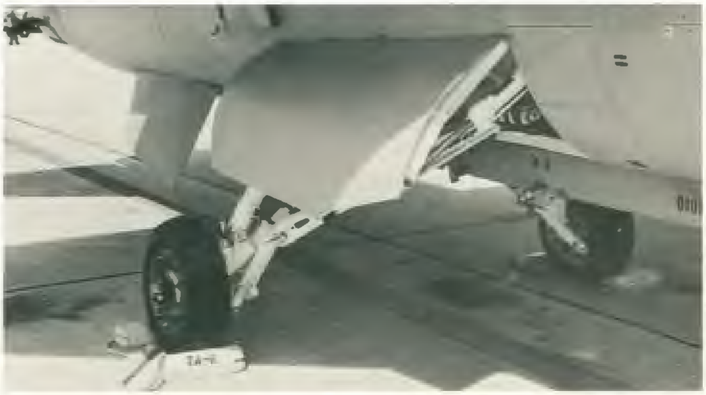
Horizontal stabilators are primarily composite construction. Aerofax



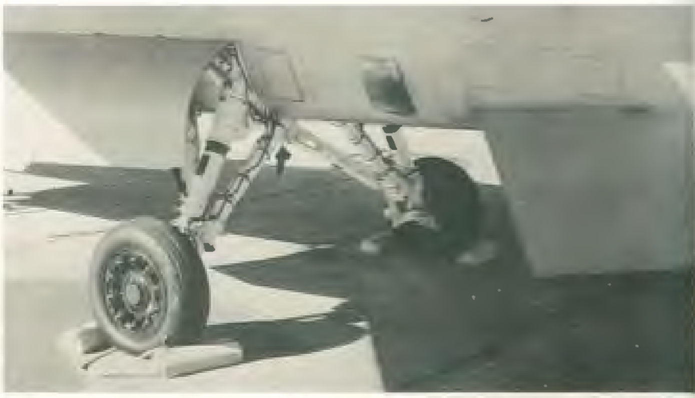
Ventral fins have hexagonal airfoil secton and single point mounting. Aerofax



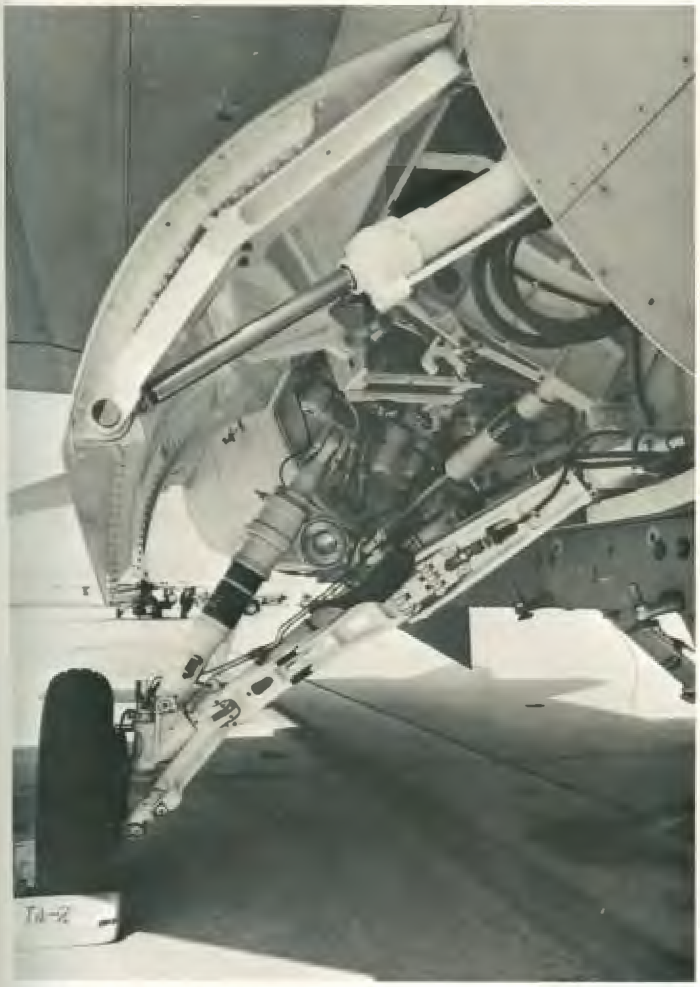
Main gear wheels are usually painted black, white, or grey. Aerofax



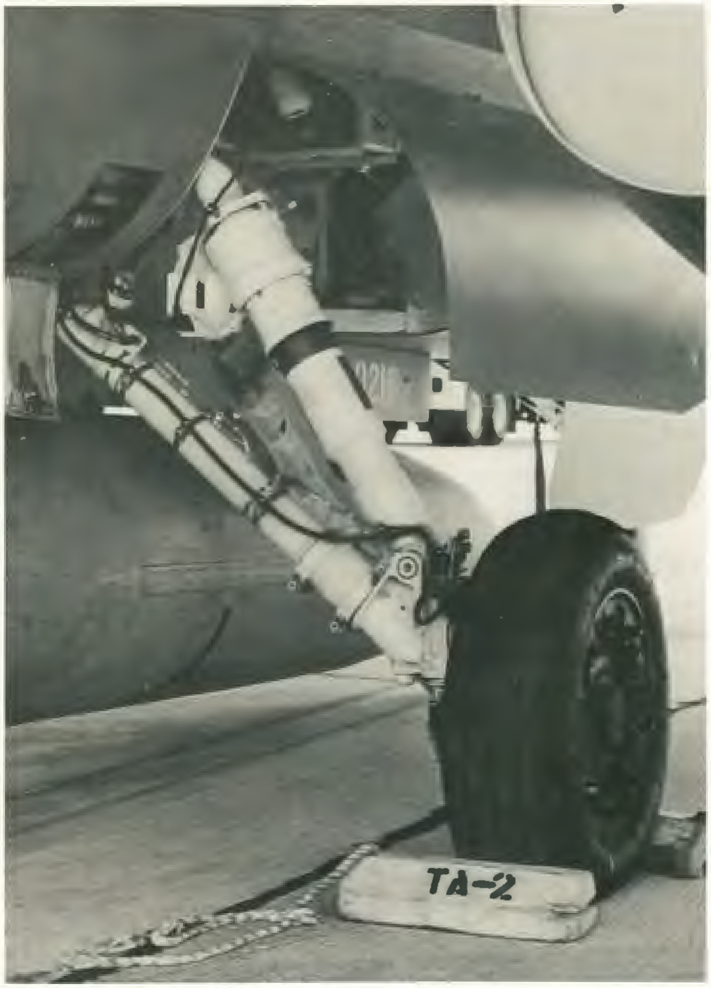
Front view of main gear and gear well door. Aerofax



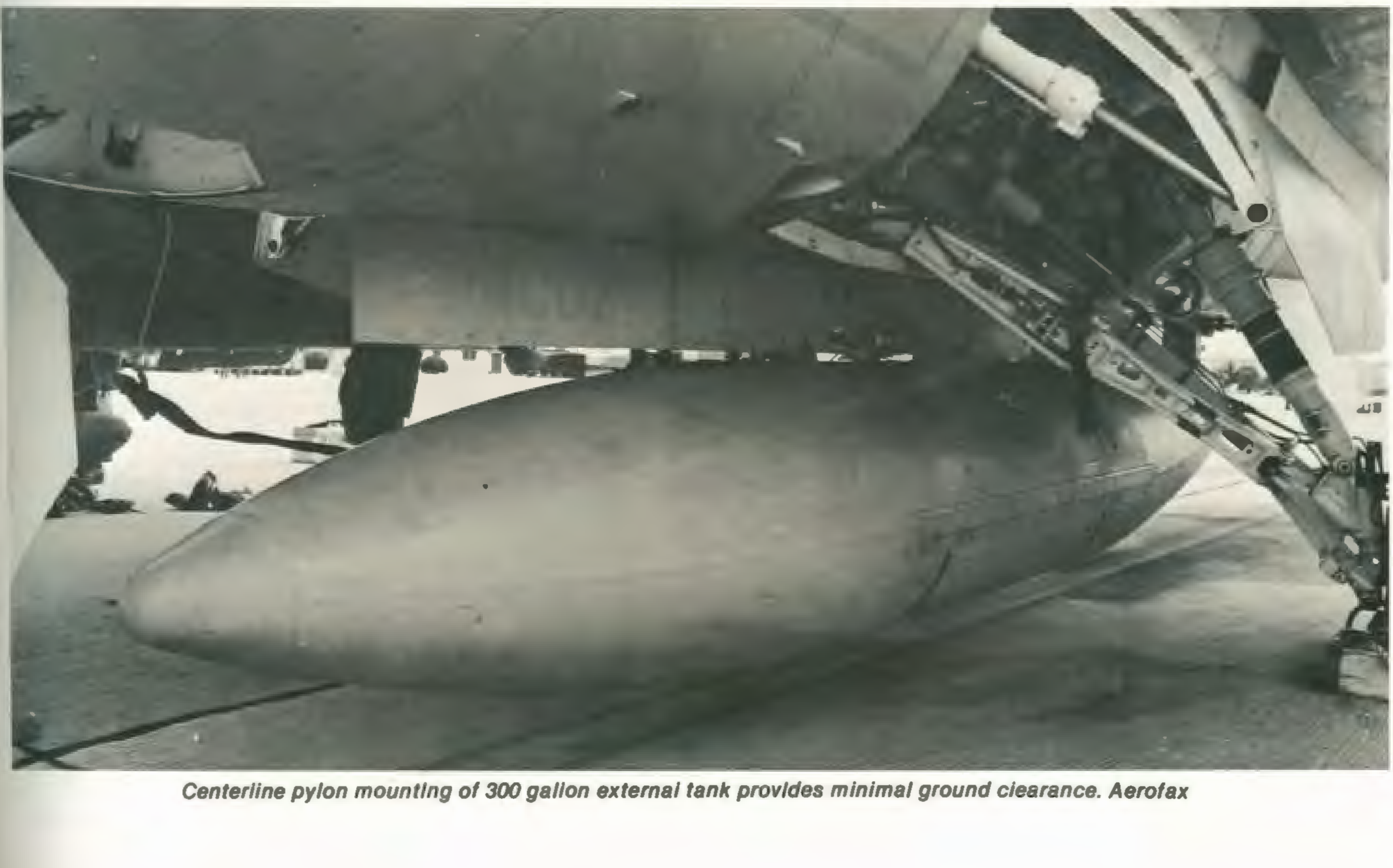
Rear view of main gear and gear well door. Aerofax



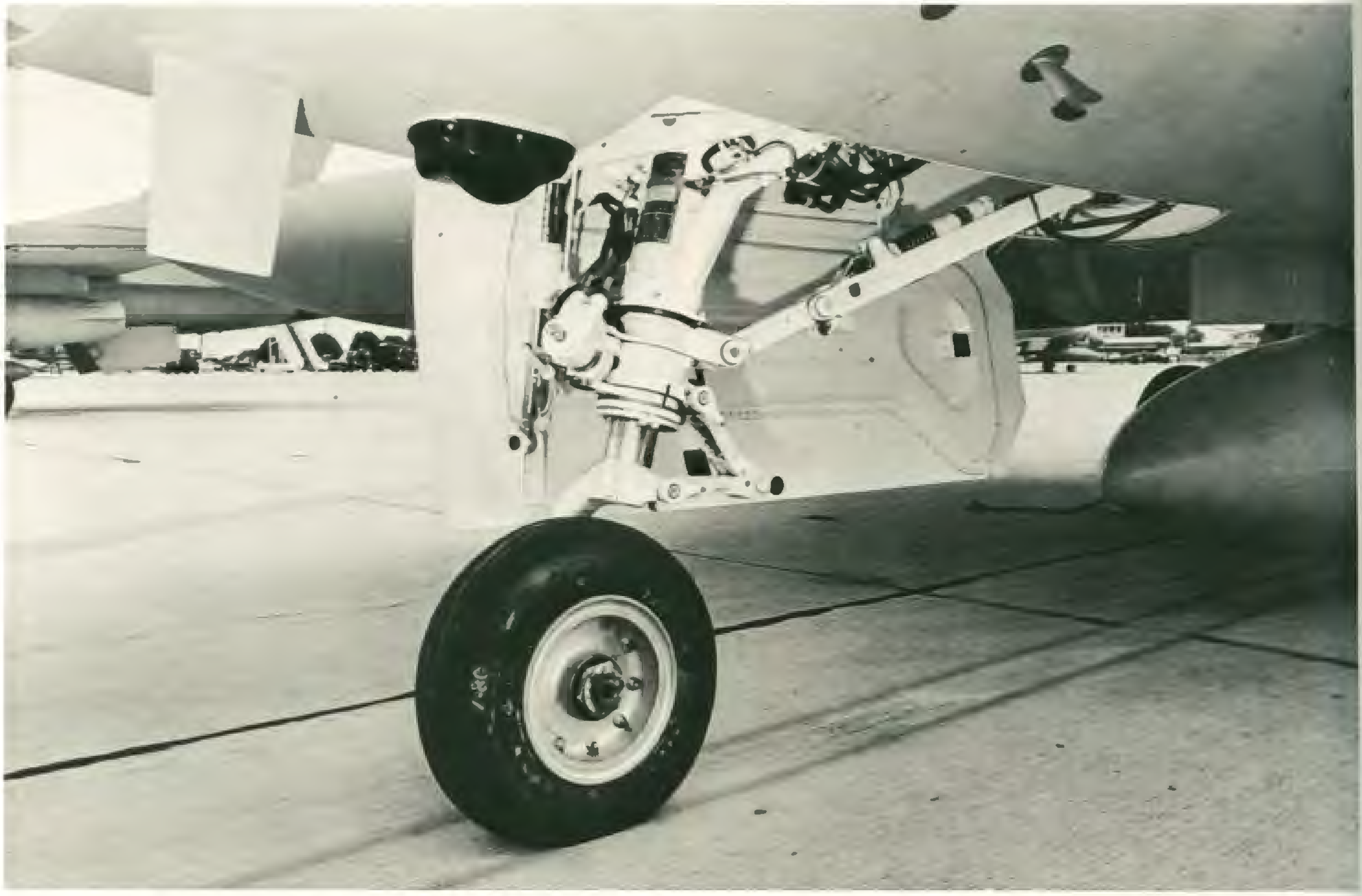
Detail view of main gear and gear well, looking aft. Note main gear landing light in center, gear door hydraulic actuator, and main shock strut. Aerofax



Detail view of main gear and gear well, looking forward. Mounted on aircraft centerline pylon is 300 gallon external drop tank. Aerofax



Centerline pylon mounting of 300 gallon external tank provides minimal ground clearance. Aerofax



*Nose gear details include scissor link and steering actuator. Note threat warning receiver antenna. Aerofax*

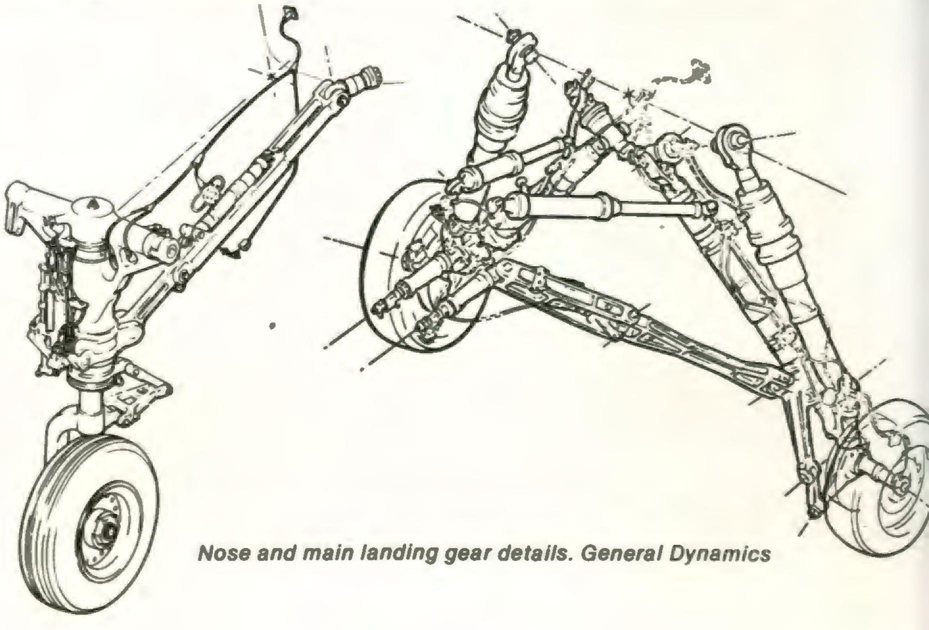
*Front view of nose gear details nose gear door and strut, and off-set lower IFF/UHF communications antenna. Aerofax*

scissor link is provided so that the nosewheel can be turned beyond the steerable range. The nosewheel steering system is electrically engaged and hydraulically powered. The pilot provides steering signals through the rudder pedals. Nosewheel steering is limited to 32-degrees in each direction.

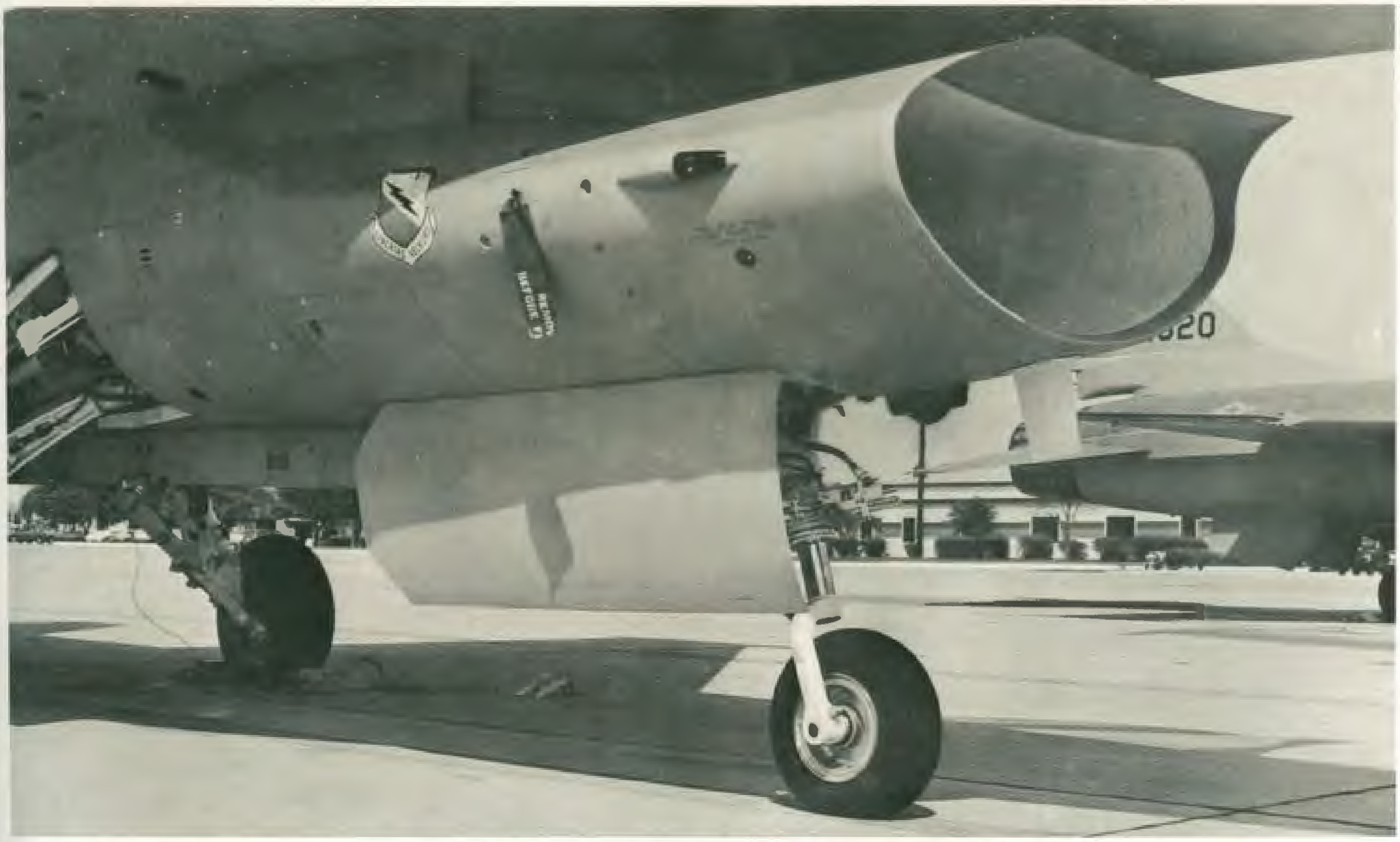
The main landing gear, equipped with Goodyear wheels and brakes and Goodrich 25.5 x 8-14 tires, are retracted hydraulically but extend by free-fall assisted by airloads. All the landing gear doors are hydraulically actuated with electrical sequencing provided during retraction and mechanical sequencing during extension.

Each main gear has a Goodyear manufactured aluminum alloy wheel equipped with fusible metal thermal pressure relief plug. The two main gear are independent of each other and retract forward with a mechanical whee twist into two separate wells.

Each main landing gear wheel is equippe with a hydraulically operated, double elemen multiple disc brake. The brakes are controlle by conventional toe-type brake pedals on the



*Nose and main landing gear details. General Dynamics*



*Fixed-geometry intake and nose landing gear details. Note position light and boundary layer bleed slot (above unit patch). Aerofax*

rudder control and are spring-loaded to permit a 1" travel at the pedal tip. A dual transducer attached to the pedals generate a brake signal proportional to the foot pressure applied. A Goodyear anti-skid system with touchdown skid control, proportional skid control, locked wheel skid control, and anti-skid failure detection is provided.

The landing light is mounted on the left main landing gear strut. The taxi light is on the right main landing gear strut.

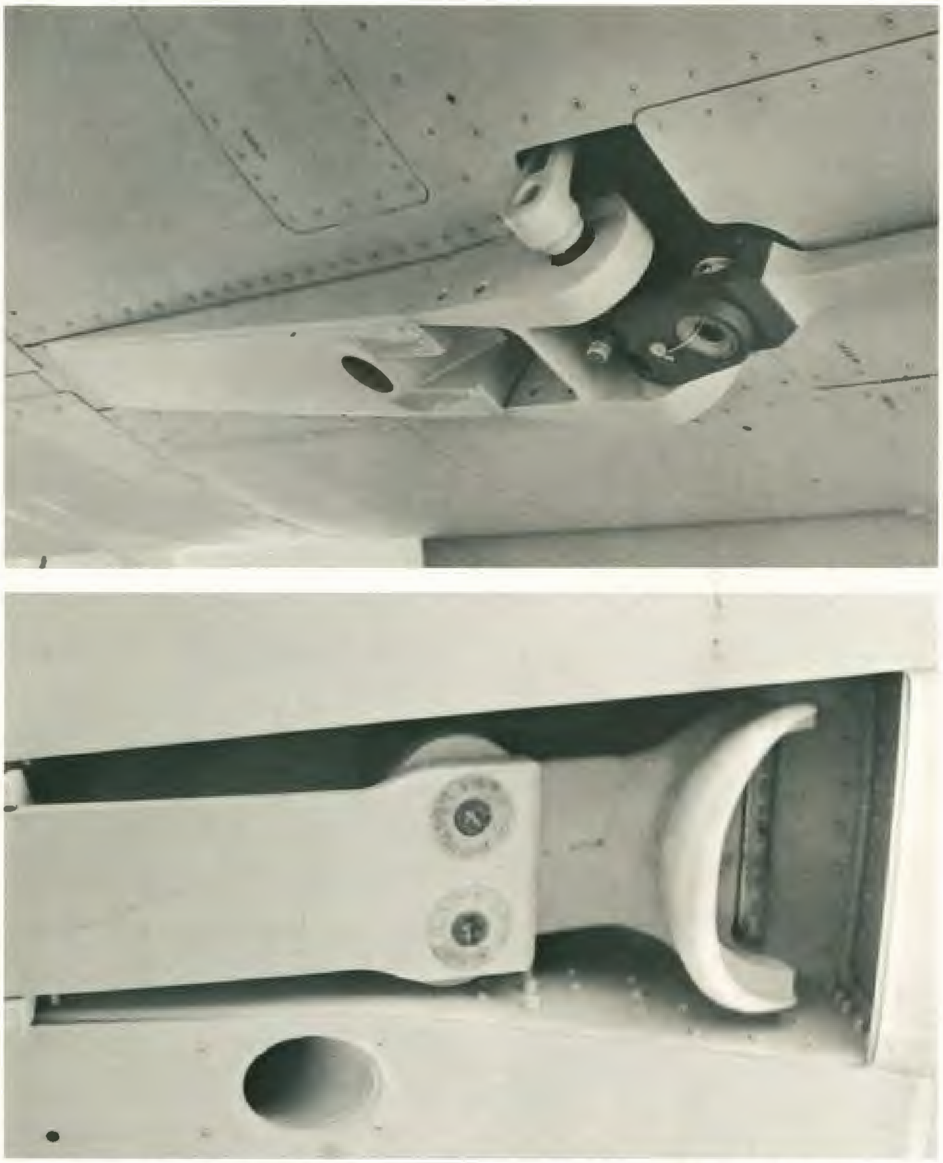
*Speedbrake System*—The speedbrake system consists of two pairs of clamshell surfaces located adjacent to the engine exhaust nozzle and inboard of the horizontal tail surfaces. Each surface will open to 60-degrees in 2 to 3 seconds at traffic pattern speeds. However, unless overridden by the pilot, speedbrake extension is limited to 43-degrees in flight with the landing gear extended (thus preventing over-rotation damage during landing).

*Drag Chute System* (on Norwegian and #2 FSD airplane only, but scheduled for late production aircraft under MSIP program)—A drag chute is provided to reduce landing rollout distance. The chute is deployed by an actuator powered by hydraulic system B that is electrically actuated by a cockpit switch. A spring-loaded pilot chute is utilized to pull the main chute from a storage bag located in an aerodynamic fairing below the rudder and aft of the rudder servoactuator. The chute has a maximum deployment speed of 170 knots.

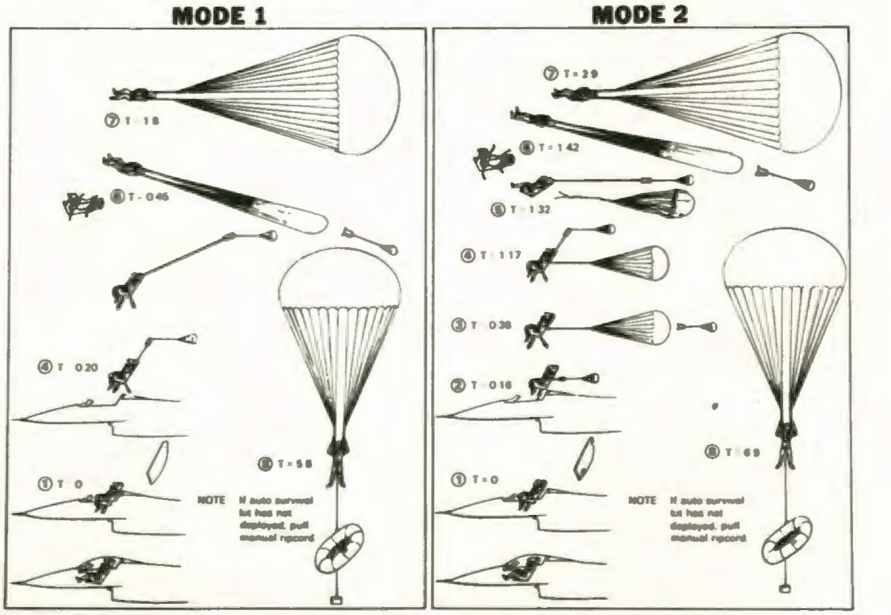
*Arrestment System*—The aircraft is equipped with an arresting hook for emergency and special case arrestment. The arresting hook is electrically controlled and pneumatically operated.

*Cockpit*—The cockpit is enclosed by an electrically operated clamshell canopy with a polycarbonate transparency. Windscreen/canopy design provides 360-degree

*Two views of speed brake in open and closed positions. Brake is hydraulically actuated and can be used throughout much of the F-16's flight envelope. General Dynamics/Aerofax*



*Two views of the under-aft-fuselage-mounted arresting hook. This is used primarily for emergency landing situations and is actuated from the cockpit. Aerofax*


MODE 1
⑦ T 18
⑥ T - 046
④ T 020
⑧ T = 58
① T 0
NOTE If auto survival kit has not deployed, pull manual ripcord
MODE 2
⑦ T = 29
⑥ T = 1 42
⑤ T 1 32
④ T 1 17
③ T 038
② T 016
⑧ T 69
① T = 0
NOTE If auto survival kit has not deployed, pull manual ripcord

*Low and high altitude ejection with ground level zero-zero capability are all built into the F-16's ACES (Advanced Concept Ejection Seat) II ejection seat. General Dynamics/USAF*

all-round view, 195-degrees fore and aft, 40-degrees down over the side, and 15-degrees down over the nose. A toggle switch on the forward left side of the cockpit is positioned up or down to actuate it. Depressing either button and pulling the T-handle on the left side of the cockpit initiates the canopy jettison sequence independent of seat ejection.

The McDonnell Douglas Aces-II ejection seat (the two YF-16's were equipped with Escapac seats, and the eight FSD F-16A's were equipped with Stencel SIIIS seats) operates in one of three automatic airspeed/altitude modes. The ejection handle is sized for single- or dual-handed operation and requires a pull of 40 to 50 pounds to actuate. Initiating the seat ejection sequence retracts and locks the inertia reel, fires initiators for latch release and initiates the correct recovery sequence mode by monitoring input to the environmental sensing unit. The sequencer ignites the stabilization package, the trajectory divergence rocket, and (if in mode 2 or 3) initiates the drogue gun. After seat catapult initiation in mode 1, the recovery parachute mortar fires in .20 seconds. Seat/man separation occurs .45 seconds after the initial actuation. In mode 2, the drogue gun deploys the extraction chute which deploys the drogue chute. The recovery parachute is deployed 1.17 seconds after catapult initiation. Seat/man separation occurs 1.42 seconds after catapult firing. In mode 3, the drogue chute deploys and pitch control operates as in mode 2, but subsequent events (seat/man separation, parachute deployment, etc.) are delayed until mode 2 conditions exist.

The cockpit is conventional except for the ejection seat which is reclined 30-degrees, and the normal center mounted flight control stick has been replaced by a right console mounted side stick. This side stick is a force-sensing unit containing transducers in both pitch and roll axes. Maximum nose up and nose down pitch commands are generated by 31 and 18 pound pilot inputs, respectively (some aircraft have 32 pound input requirements for both). Maximum roll commands are generated by 17 pounds of pilot input in cruise configuration and by 13 pounds of pilot input with the landing gear down, with the alternate flaps switch in the extend position, or with the air refuel door open. The instrument panel is located and arranged to increase accessibility and visibility.

The rudder pedals are minimum deflection force-sensing units containing transducers. Force on the applicable rudder pedal produces electrical yaw command signals. These signals are routed to the flight control computer for processing. The resulting signals are sent to the rudder integrated servoactuator to position the rudder. The rudder pedals are also used to generate brake and nosewheel steering signals.

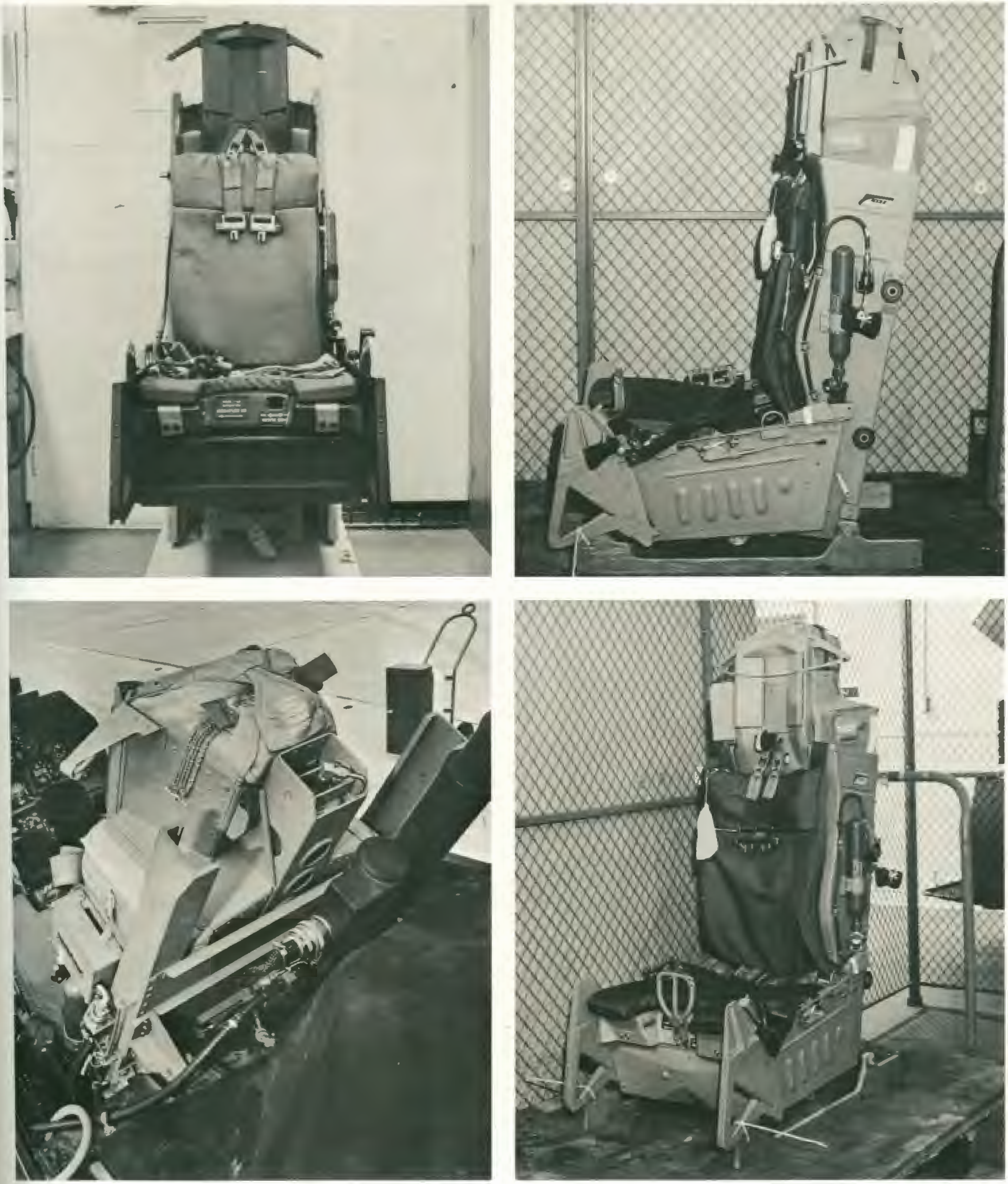
Pilot command signals to the flight control computer are initiated by applying force to the side stick and rudder pedals. These command signals are processed by the flight control computer along with signals from the air data system, flight control rate gyros, and accelerometers. The processed signals are transmitted to the integrated servoactuators of the horizontal tails, flaperons, and rudder, which are positioned to give the command response. The cockpit contains no circuit breakers.

The United Technologies' Hamilton Standard Division air conditioning and pressurization systems are combined to provide temperature-controlled, pressure regulated air for heating, ventilating, pressurization, pressurization for the canopy seal, and use as servo air. This system also provides air to cool and pressurize the electronic equipment, to perform windshield defogging, and to supply anti-g suit and fuel tank pressurization.

The primary oxygen system, consisting of a 5-liter liquid oxygen system providing breathing oxygen to a pressure demand regulator, is backed up by an emergency gaseous system.

*Air Data System*—The air data system utilizes probes and sensors to obtain static and total air pressures, angle of attack, sideslip, and air temperature inputs. These air data parameters are processed and supplied to various systems.

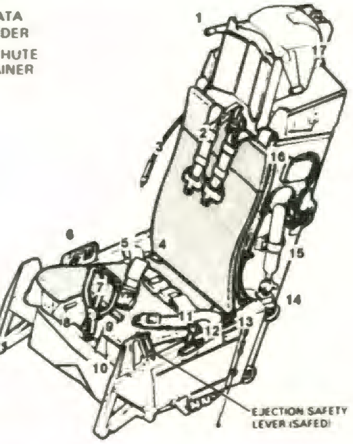
*Electrical Power System*—The electrical power system includes an ac power generating system, an emergency ac power generating system, a dc power generating system, a flight control system power supply, a power distribution and control system, and provision



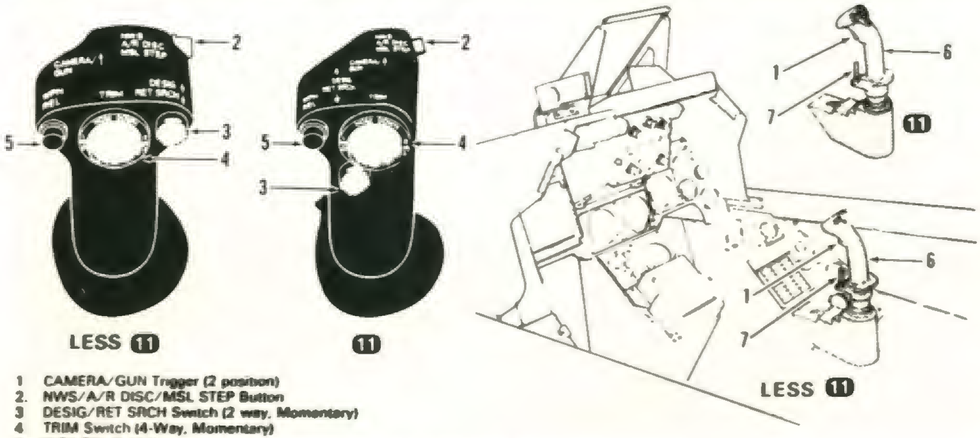
*Four views of F-16 ACES II ejection seat details harnessing for pilot, emergency oxygen bottle, seat padding, headrest, support rails, and miscellaneous items. Aerofax/General Dynamics/McDonnell Douglas*

*Side stick moves only slightly during control inputs from pilot. Large lever at base of side stick is paddle switch for interrupting the autopilot during flight. James Goodall*

1 ENVIRONMENTAL SENSOR PITOTS
2 PARACHUTE RISERS
3 EMERGENCY OXYGEN FITTING
4 SURVIVAL KIT MANUAL RIPCORD (UNDER SEAT PAN)
5 LAP AND SURVIVAL KIT ATTACHMENT STRAPS
6 RESTRAINT EMERGENCY RELEASE HANDLE
7 EJECTION HANDLE
8 SURVIVAL KIT DEPLOYMENT MODE SWITCH
9 SURVIVAL KIT (UNDER SEAT PAN)
10 RADIO BEACON SWITCH
11 INERTIA REEL KNOB
12 EMERGENCY OXYGEN MANUAL ACTIVATION RING
13 EMERGENCY OXYGEN PRESSURE GAGE
14 EMERGENCY OXYGEN BOTTLE
15 FCS DATA RECORDER
16 PARACHUTE CONTAINER



*ACES II ejection seat details. General Dynamics/USAF*



1 CAMERA/GUN Trigger (2 position)
2. NWS/A/R DISC/MSL STEP Button
3 DESIG/RET SRCH Switch (2 way, Momentary)
4 TRIM Switch (4-Way, Momentary)
5 WPN REL Button
6 Side Stick Grip
7 Paddle Switch

*Side stick details. General Dynamics/USAF*

for an external power source.

Electrical power is normally supplied by a Westinghouse 40 kva generator located on the airframe mounted gearbox. This unit supplies 115/200 volt, 400 hertz power to the two ac power panel essential and nonessential buses. There is also a Lear Siegler 5 kva generator and associated generator ground control units with Sundstrand constant-speed drive.

The 28 vdc electrical power is supplied by a battery rated at 25.2 volts nominal and two ac-to-dc, 100 amp converters which receive power from either the primary generator, the emergency generator, or the external power unit. DC loads are supplied from two isolated dc buses and a battery bus. Battery power is supplied to the battery bus through the battery control relay when the output from both converters is lost and the power switch is not in the OFF position.

*Lighting System*—All of the exterior lights, except the landing/taxi lights and air refueling slipway lights, are controlled from the cockpit mounted exterior lighting control panel. The airplane is equipped with an anti-collision light on the top center of the vertical fin; position lights on the wing (at tip, top, and bottom), inlet (left and right), tail (on trailing edge of vertical fin near fuselage), and fuselage (on top side of fuselage on either side just forward of the speedbrakes); formation lights on the wing (at tip, top, and bottom) and fuselage (top and bottom); an air refueling receptacle light; and an identification light in the left-hand forward equipment bay door.

All of the interior lighting, which consists of control panel and instrument panel lighting, a utility light, a cockpit spotlight, and secondary (flood) lighting, is controlled from a cockpit mounted interior lighting control panel.

*Hydraulic Power Supply System*—Hydraulic power is supplied by two independent hydraulic systems designated as systems A and B. Both systems operate simultaneously to supply hydraulic power for the primary flight controls and leading edge flaps. If one of the systems should fail, the remaining system will provide sufficient hydraulic pressure for normal operation of the primary flight controls and leading edge flaps; however, the maximum actuation rate will be reduced. System A also supplies power to the fuel flow proportioner and the speedbrakes. All remaining utility functions, consisting of the gun and gun purge door, air refueling system, landing gear, brakes, nosewheel steering, throttle boost, drag chute system, and the jet fuel starter are supplied power by system B. Hydraulic pressure for each system is supplied by an engine-driven, variable displacement pump located on the accessory drive box.

*Emergency Power Unit*—The Garrett-manufactured EPU is an automatic, self-contained, system that provides simultaneous generation of emergency hydraulic and electrical power regardless of aircraft attitude, altitude, or Mach number. The EPU uses engine bleed air and/or hydrazine monopropellant fuel to drive an emergency hydraulic pump and a 5 kva emergency generator. The EPU is automatically activated when (1) both hydraulic systems pressures fall below 1,000 psi, or (2) when the main generator disconnects from the bus system.

*Fuel System*—Internal fuel is contained in the fuselage and wing. Additional fuel can be carried in external tanks. The fuel system incorporates both in-flight and single-point ground refueling capabilities. The aircraft has seven internal fuel tanks located in the fuselage and wings that are integral to the structure. There are provisions for carrying three external tanks. The capacity of F-16A and F-16B fuel tank systems are identical except for the forward F-1 tank. This tank has been reduced in size for the F-16B to allow room for the rear cockpit. In the F-16A, the forward fuel tanks (F-1 and F-2) have larger capacities than the aft tank (A-1), while in the F-16B the aft tank (A-1) has a greater capacity than the forward tank (F-1 and F-2).

Five of the internal tanks are storage tanks. These are the left and right wing tanks, two forward fuselage tanks (F-1 and F-2), and the aft fuselage tank (A-1). The other two internal tanks are the forward and aft reservoirs which supply fuel directly to the engine.

The external tanks can be carried on wing and centerline pylons. When carried, they approximately double the fuel capacity of the aircraft. Due to its location next to the gun, the F-1 tank has a redundant bladder liner to insure that fuel will not leak into the gun or ammunition area.

Fuel is transferred by two independent methods. The primary method is by siphoning action through standpipes that connect the fuel tanks. A powered transfer system serves as a backup fuel transfer method in the internal tanks. It also scavenges tanks to minimize unusable fuel by using electrically driven pumps and pumps powered by bleed fuel pressure from the engine manifold. Both methods operate simultaneously and independently to transfer fuel through the system.

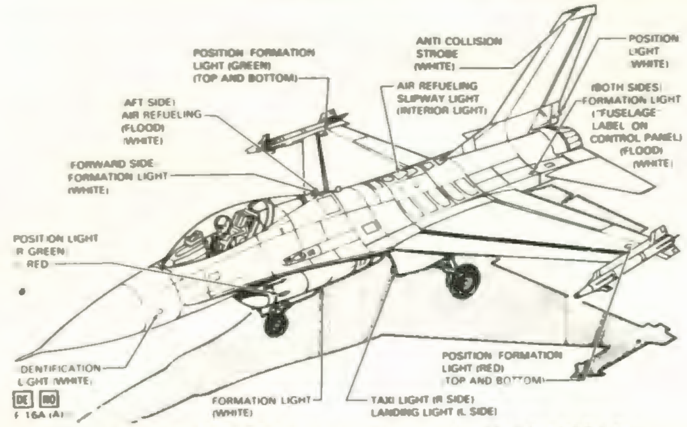
All external and internal fuel tanks in the aircraft can be pressure filled from a single refueling receptacle located on the lower left side of the fuselage just forward of the wing trailing edge. The air refueling system consists of a hydraulically actuated receptacle and slipway door, a signal amplifier, and the associated controls and indicators.

*Fire Control System and Armament*—The fire control system includes a fire control radar with search and tracking capability, a radar electro-optical (REO) display, and a head-up display (HUD). A store management system (SMS) presents a control panel and visual display to the pilot for inventory, control, and release of all stores. Basic armament includes a fuselage mounted multibarrel 20mm gun and an air-to-air missile on each wingtip. Additional stores of various types can be carried on pylons mounted under the wings and on the fuselage centerline.

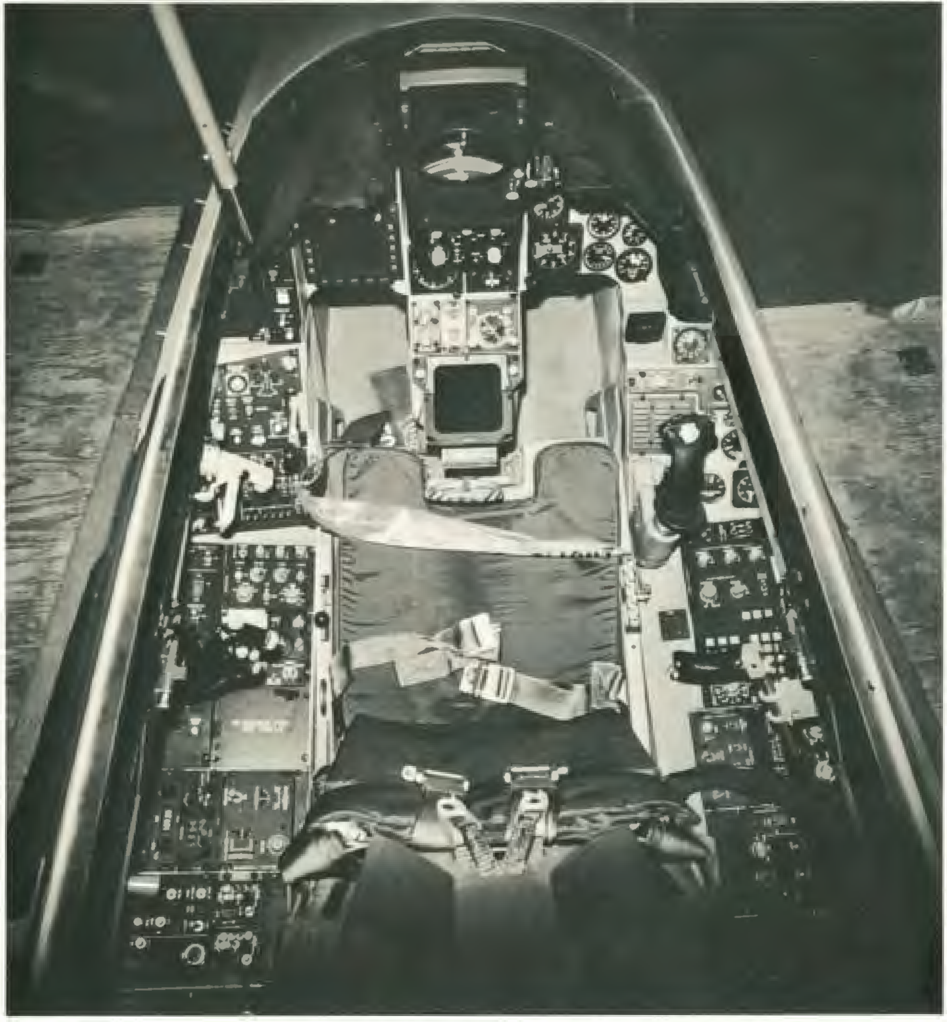
The 6,000 rounds-per-minute capability General Electric M61A-1 20mm rotary cannon, mounted in the port-side wing body fairing, is coupled to an ammo conveyer and ammo drum storage unit, all hydraulically driven. The drum provides storage for 515 rounds of linkless ammo and space for retaining all empty and misfired cartridges. The conveyer transports live ammo from the drum to the gun and returns empties, misfires, and cleared rounds to the drum.

Ventilation for gun cooling and gas venting is provided by fixed vents on the upper and lower sides of the left strake and the lower side of the right strake and a hinged gas purge door under the gun aft section. The gas purge door opens when the trigger is depressed and closes when the trigger is released.

Gun selection is accomplished through the stores control panel. Aiming is performed by using the symbology presented on the HUD. Snapshoot, lead computing optical sight, and strafe modes of operation are provided for gun aiming.


POSITION FORMATION LIGHT (GREEN) (TOP AND BOTTOM)
ANTI COLLISION STROBE (WHITE)
POSITION LIGHT (WHITE)
AFT SIDE) AIR REFUELING (FLOOD) (WHITE)
AIR REFUELING SLIPWAY LIGHT (INTERIOR LIGHT)
(BOTH SIDES) FORMATION LIGHT ("FUSELAGE" LABEL ON CONTROL PANEL) (FLOOD) (WHITE)
FORWARD SIDE FORMATION LIGHT (WHITE)
POSITION LIGHT R GREEN L RED
IDENTIFICATION LIGHT (WHITE)
DE
RO
F 16A (A)
FORMATION LIGHT (WHITE)
TAXI LIGHT (R SIDE) LANDING LIGHT (L SIDE)
POSITION FORMATION LIGHT (RED) TOP AND BOTTOM

*External lighting details. General Dynamics/USAF*



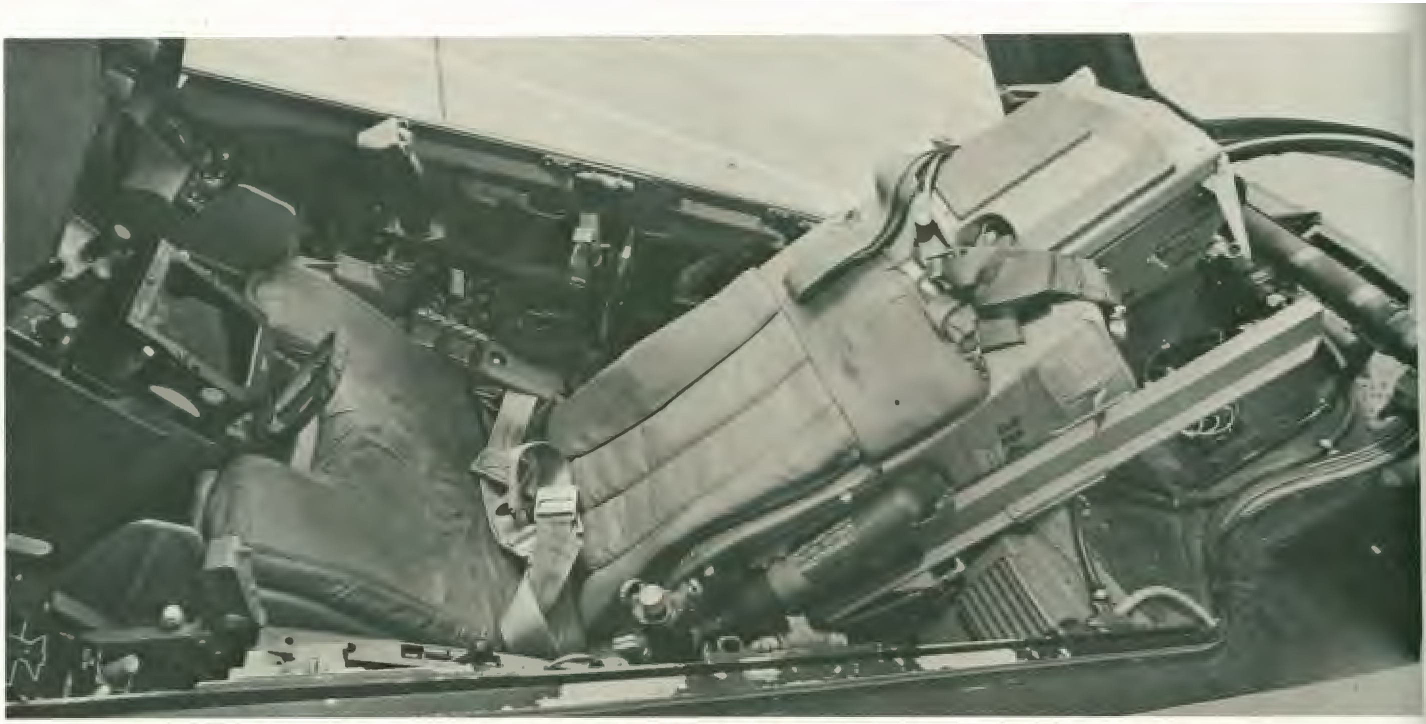
*Block 1 F-16A cockpit shows location of throttle quadrant (on left), side stick (on right), and HUD (top center). General Dynamics*

There is a mounting at each wing tip for a single air-to-air missile, usually of the AIM-9J/L type, one underfuselage centerline hardpoint, and six underwing hardpoints for additional stores. For maneuvering flight at 5.5 g, the underfuselage station is stressed for a load of up to 2,200 pounds, the two inboard underwing stations for 4,500 pounds each, the two center underwing stations for 3,500 pounds each, the outboard underwing stations for 700 pounds each, and the two wingtip stations for 425 pounds each.

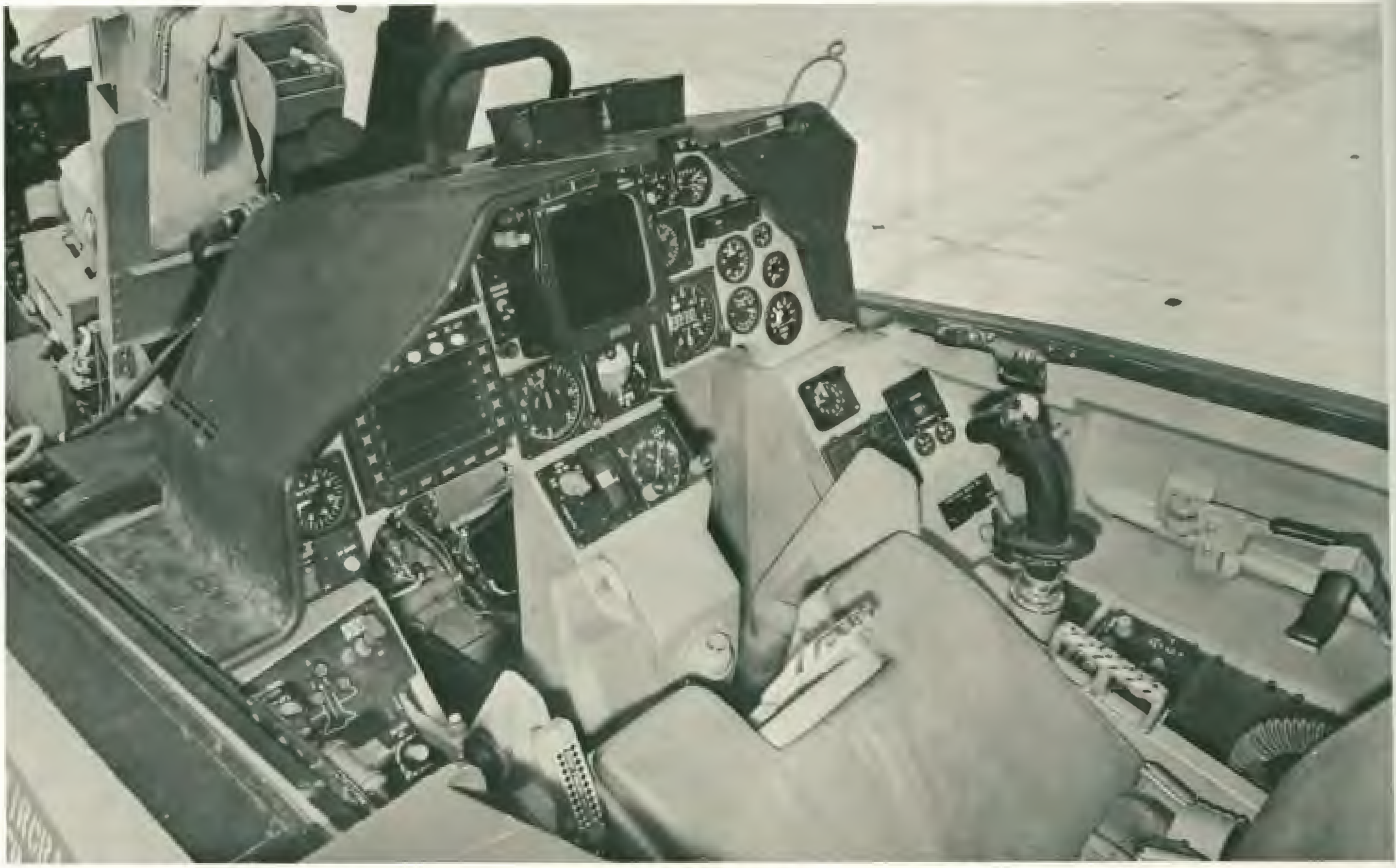
For maneuvering flight at 9 g the underfuselage station is stressed for a load of up to 1,200 pounds, the two inboard underwing stations for 2,500 pounds each, the two center underwing stations for 2,000 pounds each, the two outboard underwing stations for 450 pounds each, and the two wingtip stations for 425 pounds each. The total possible external weapon load is 20,450 pounds, and for 9 g maneuver capability, 11,950 pounds.

There are mounting provisions on each side of the inlet shoulder for the specific carriage of sensor pods and each of these stations is stressed for 900 pounds at 5.5 g and 550 pounds for 9 g.

Typical store loads can include two wingtip-



***Full view of F-16 ACES II ejection seat illustrating 30-degree tilt for improved g tolerance. Aerofax***

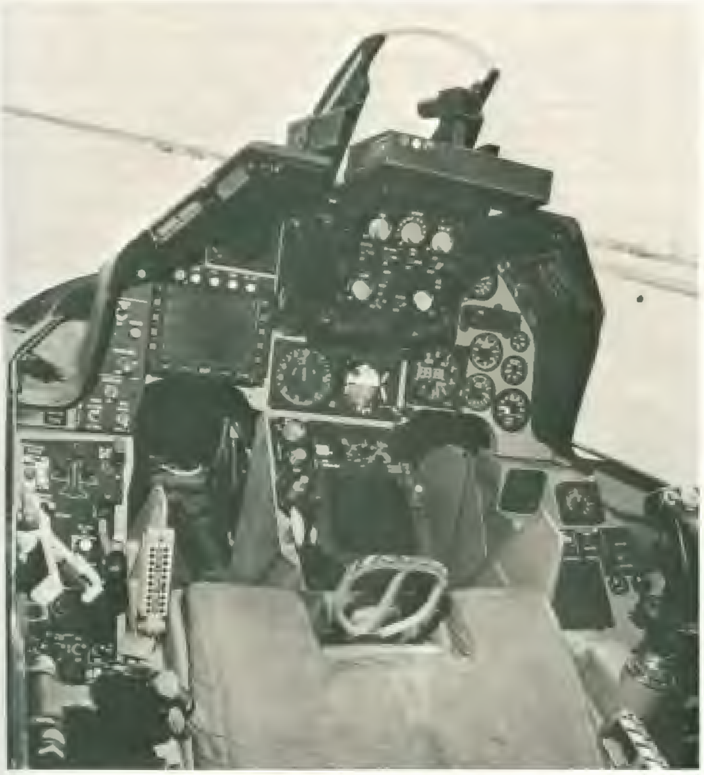


***Late Block 1 F-16B rear instrument panel. Note side stick and armrest (for high g maneuvering). Aerofax***

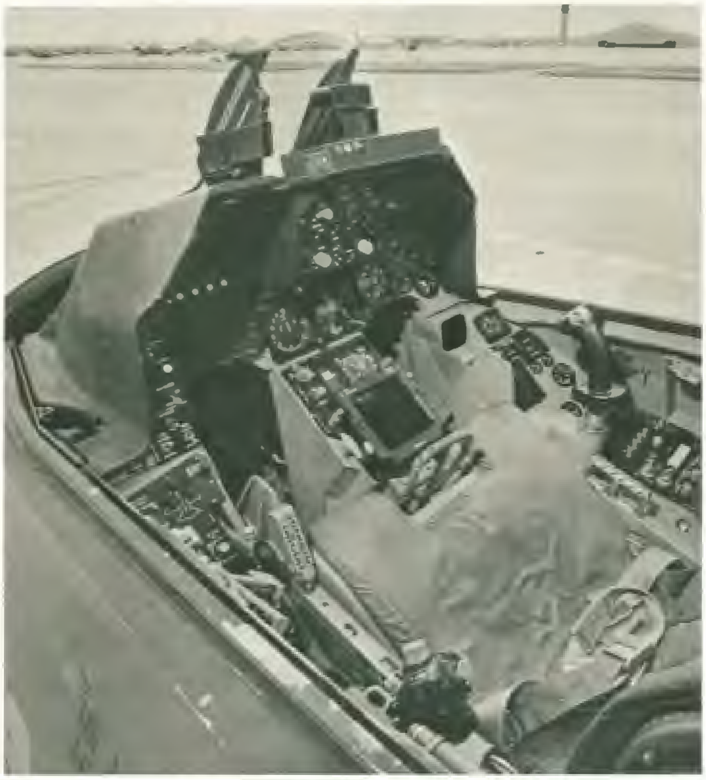
mounted AIM-9J/L's, with up to four more on the outer underwing stations; Sargent-Fletcher 370 gallon drop tanks on the inboard underwing stations; a 300 gallon drop-tank or a 2,200 pound bomb on the underfuselage station; a Martin Marietta *Pave Penny* laser tracker pod along the starboard side of the nacelle; and single or cluster bombs, air-to-surface missiles, or flare pods, on the four inner underwing stations. Stores can be launched from Aircraft Hydro-Forming MAU-12C/A bomb ejector racks, Hughes LAU-88 launchers, or Orgen triple or mutiple ejector racks.

Westinghouse AN/ALQ-119 and AN/ALQ-131 ECM (jammer) pods can be carried on the centerline and two underwing stations. Modified Tracor ALE-40 internal pyrotechnic/chaff dispensers have been specified (an ejector is located on the underside of the fuselage/wing blend just behind the trailing edge of the wing).

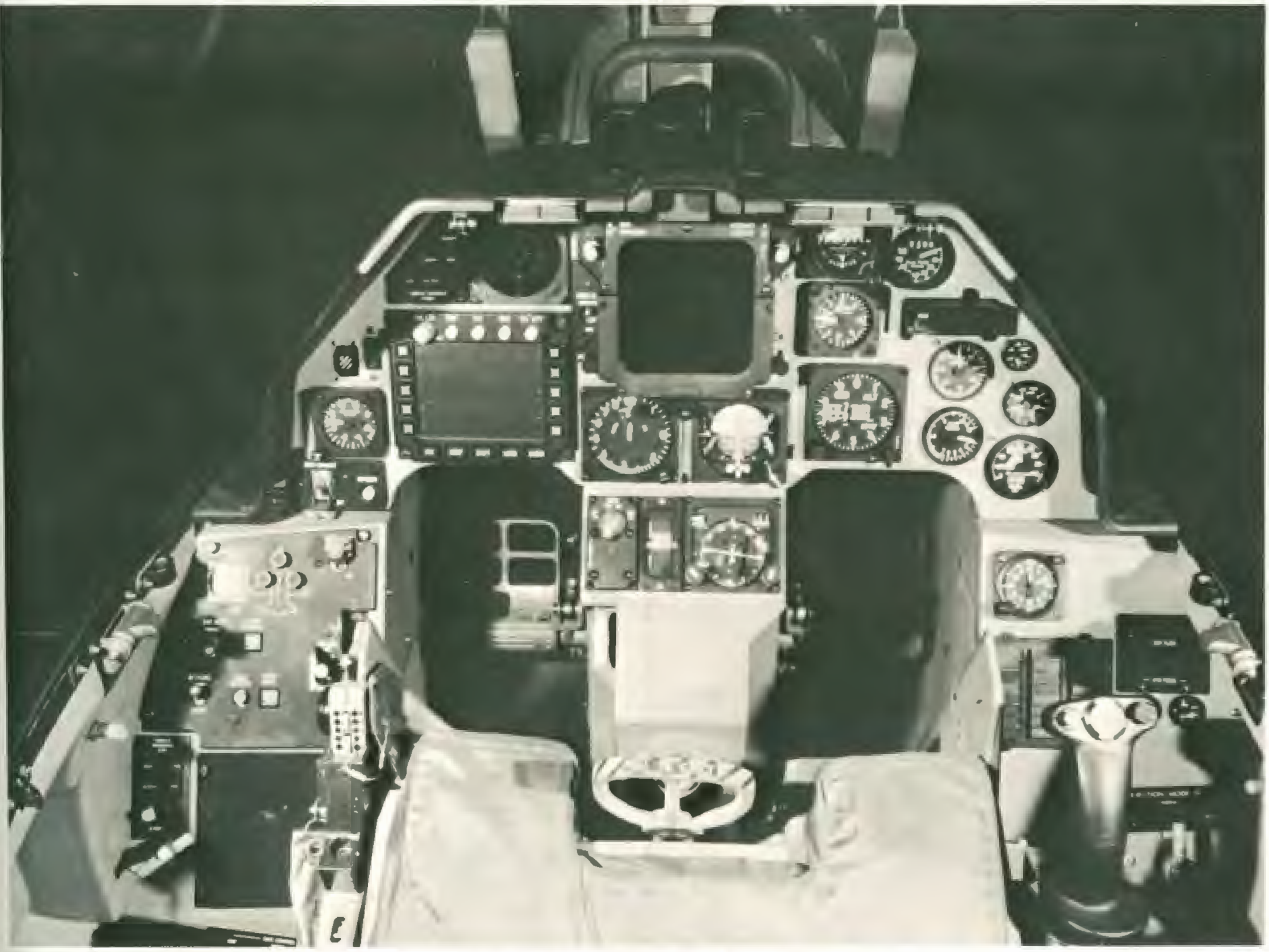
*Radar, Miscellaneous Avionics, and Equipment*—The Westinghouse APG-66 radar with nose-mounted planar array, is a multimode, medium/low PRF, coherent pulse-doppler unit which provides air-to-air search, detection, and track capabilities, surface mapping, and air-to-surface ranging. Digital processing is employed to eliminate false air-to-air targets allowing target information to be presented on a clean scope. Automatic acquisition and track can be commanded from the



Late Block 1 F-16A instrument panel details HUD and center CRT. Aerofax



Overview of F-16A cockpit. Aerofax



Overview of early Block 1 F-16B rear cockpit. Aerofax throttle grip by selecting either "Dogfight" or "MSL". Ground map displays may be expanded for better target determination. Doppler beam sharpening (DBS) can be selected to improve ground map resolution. Air-to-surface ranging is automatically commanded for applicable weapon delivery modes and INS updates. The radar has a lookdown range in ground clutter of 25 miles, and a lookup range of 40 miles.

The threat warning system consists of eight units. Threat radars are identified and displayed as alphanumeric symbols on the azimuth indicator. Threat modes allow the selection of one mode that limits the number of threats displayed to the five of highest priority and another mode that permits the display of up to 16 threats. The display of search and unidentified radars is also provided. Automatic override of the search radar option occurs when an AI threat or SAM guidance radar activity is detected. A composite of audio tones derived from tracking radar signals and a synthetic tone associated with guidance activity is provided to the intercommunications set for monitoring. Panels for the control of electronic countermeasures pods and systems, and the chaff dispenser units are provided.

The aircraft radios provide for voice communication. The intercommunication set provides amplification of microphone and headset signals, selection of transmitters, selection/mixing of onboard receiver audio signals and ground interphone communication. Adjustable audio signals include: UHF, VHF, TACAN, ILS, IFF, threat warning system, missile, and air refueling/ground interphone.

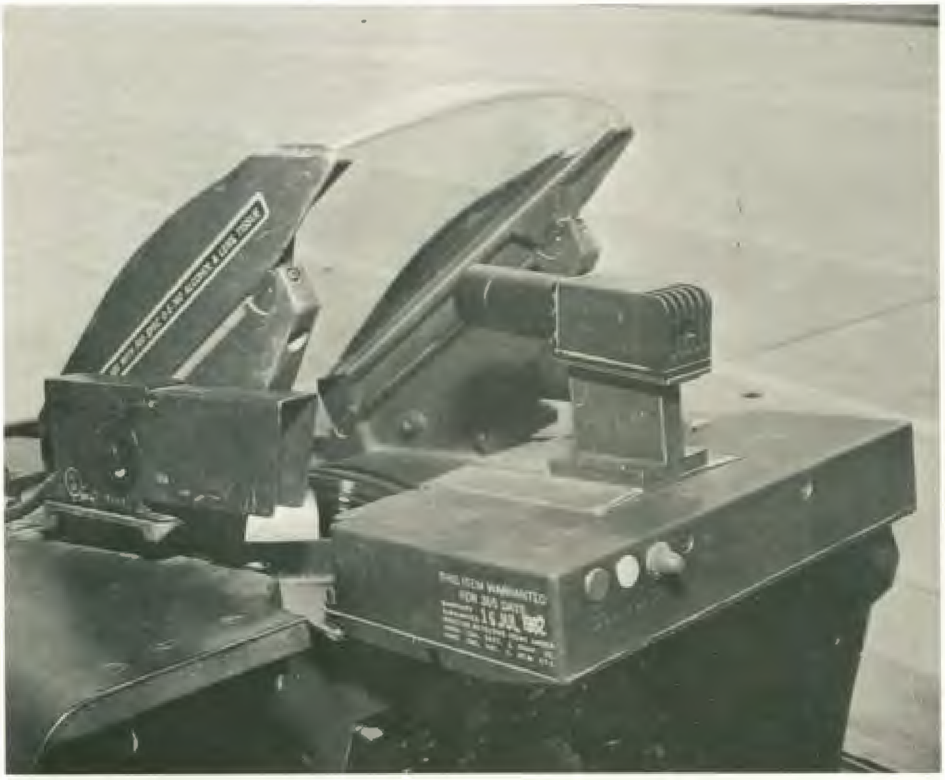
Communications equipment includes Magnovox AN/ARC-164 UHF transceiver; provisions for a Magnavox KY-58 secure voice system; Collins AN/ARC-186 VHF AM/FM transceiver; government furnished AN/AIC-18/25 intercom; and Novatronics interference blanker.

Other equipment items include: Sperry Flight Systems central air data computer; Singer-Kearfott modified SKN-2400 inertial navigation system; Collins AN/ARN-108 ILS; Collins AN/ARN-118 TACAN; Teledyne Electronics AN/APX-101 air-to-ground IFF transponder with a government furnished IFF control; government furnished National Security Agency KIT-1A/TSEC cryptographic equipment; Lear Siegler stick force sensors; Marconi Avionics electronic head-up display set; government-furnished horizontal situation indicator; Teledyne Avionics angle-of-attack transmitter; Gull Airborne angle-of-attack indicator; Clifton Precision attitude director indicator; Delco fire control computer; Photo-Sonics gun camera; Kaiser radar electro-optical display.

Essential structure and wiring provisions are built into the airframe to allow for easy incorporation of an advanced programmable signal processor radar, and future avionics systems under development for the Air Force.

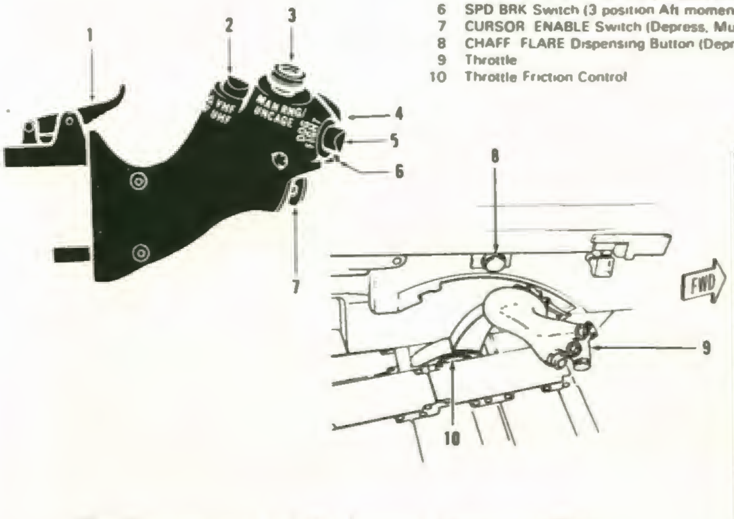
Radar related avionics are located in the forward avionics bay. This bay also contains the air data computer, the inertial navigation system, the flight control computer, and space and structural provisions for a radar altimeter. A rear avionics bay contains the instrument landing system, the TACAN and IFF, and space for future equipment.

*Head-Up Display*—The Marconi-manufactured HUD presents visual flight and weapon delivery information in a forward collimated image that is optionally superimposed on the real world view. The display unit includes the control panel, combiner glass, and a cathode ray tube. The control panel provides the switches and controls necessary for presenting as well as limiting the symbology on the combiner glass. A blinking master warning signal is also presented on the combiner glass. The display unit generates and presents a standby reticle.



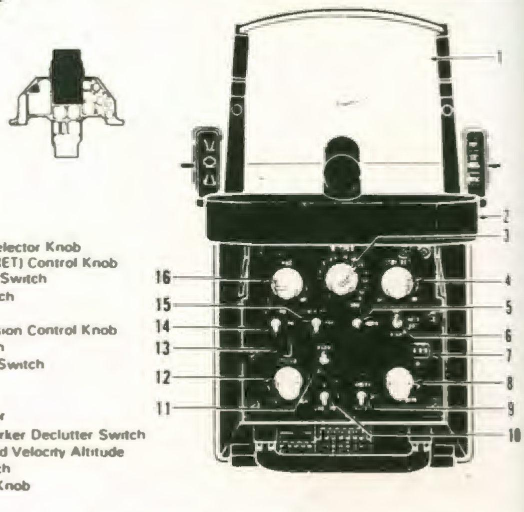
***HUD features small camera for recording imagery and target data. Camera is seen as gun-like device mounted above avionics box. Aerofax***

| | |
|---|---|
| 1 | Cutoff Release |
| 2 | UHF VHF Transmit Switch (2 way momentary Rocker) |
| 3 | MAN RNG UNCAGE Knob Switch (Rotate Depress) |
| 4 | ANT ELEV Knob (Rotate, Center Detent) |
| 5 | DOGFIGHT MSL Switch (3 position Slide) |
| 6 | SPD BRK Switch (3 position Aft momentary) |
| 7 | CURSOR ENABLE Switch (Depress, Multi Directional) |
| 8 | CHAFF FLARE Dispensing Button (Depress, momentary) |
| 9 | Throttle |
| 10 | Throttle Friction Control |



***Throttle quadrant details. General Dynamics/USAF***

| | |
|---|---|
| 1 | HUD Combiner Glass |
| 2 | Television Sensor |
| 3 | Wingspan (W SPAN) Selector Knob |
| 4 | Standby Reticle (STBY RET) Control Knob |
| 5 | DRIFT Cut out and Test Switch |
| 6 | Brightness Control Switch |
| 7 | Depression Indicator |
| 8 | Standby Reticle Depression Control Knob |
| 9 | CAMERA Control Switch |
| 10 | Speed Selector Display Switch |
| 11 | WARN RESET Switch |
| 12 | FILTER Control Knob |
| 13 | FILTER Position Indicator |
| 14 | Attitude Flight Path Marker Declutter Switch |
| 15 | Energy Management and Velocity Altitude Heading Declutter Switch |
| 16 | HUD OFF BRT Control Knob |



***HUD details. General Dynamics/USAF***

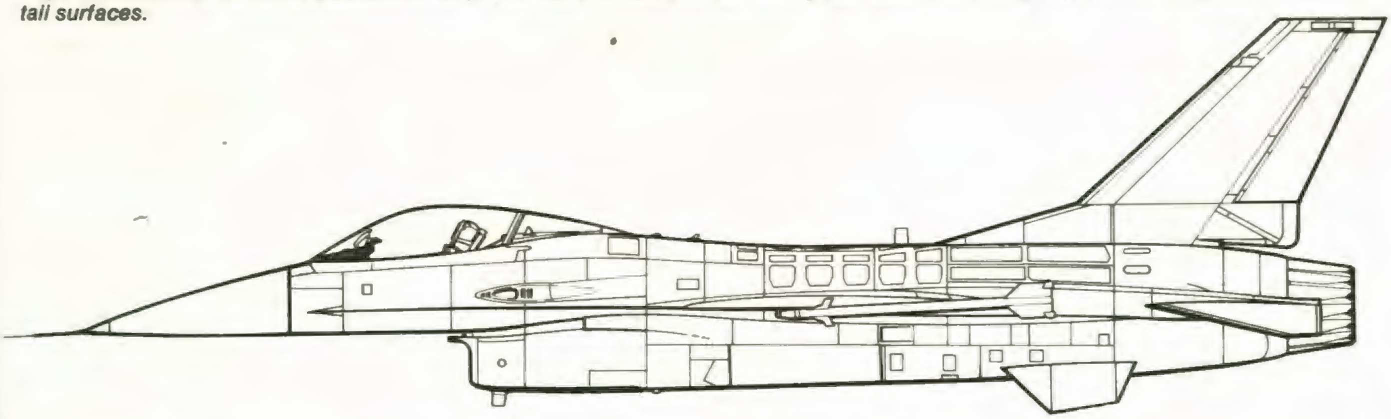
# F-16 Configurations

*The General Dynamics F-16, like almost all contemporary combat aircraft types, has gone through a number of design exercises including the seven illustrated here. Most of these perturbations are in the form of studies to improve performance (i.e., the CCV and AFTI projects) or lower production costs (i.e., the F-16/79).*

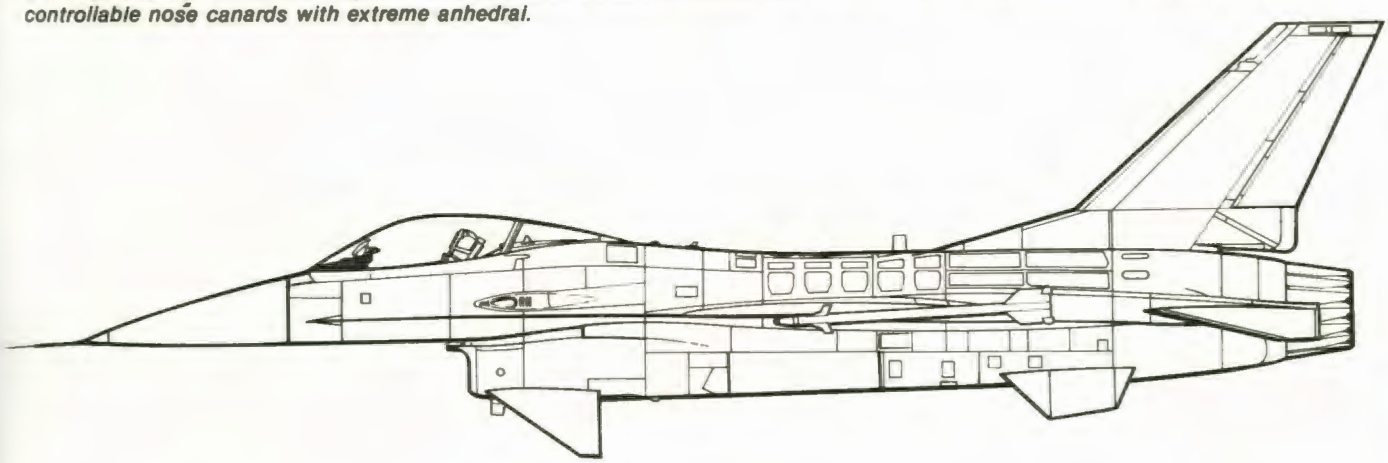
*The F-16's somewhat unique modular design has permitted an above-average amount of experimentation and the variety of projects utilizing the basic airframe bears witness to this.*

*It should be noted that the illustrations of the AFTI and "big nose" F-16 configurations are considered provisional — though they are based on the best available information at the time this book was going to press.*

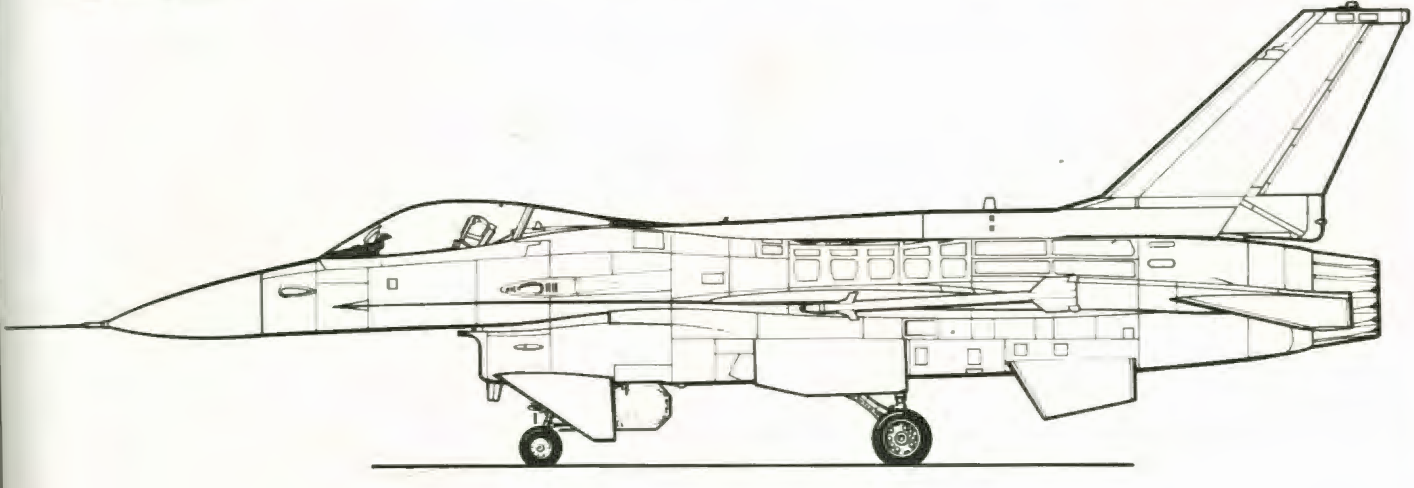
**YF-16:** *The original prototype aircraft. Differed considerably from their successors in having different and smaller noses, major dimensional variations (illustrated on p. 35), more complex nose landing gear door (two part), and smaller wing and horizontal tail surfaces.*



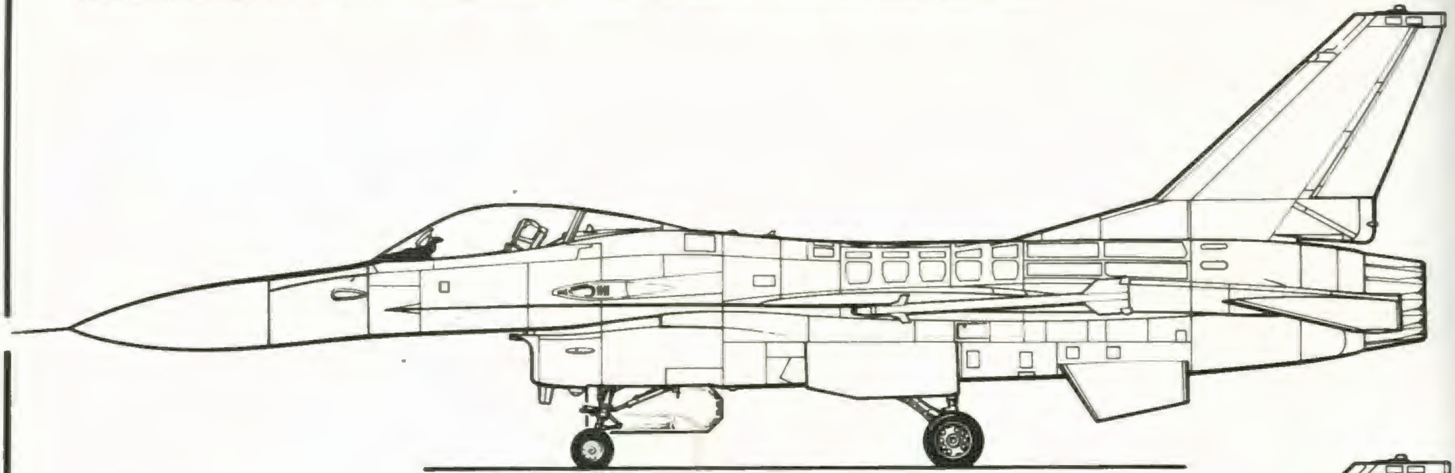
**YF-16/CCV:** *First of the major F-16 modifications. Utilized number one YF-16 airframe. Major external change was addition of controllable nose canards with extreme anhedral.*



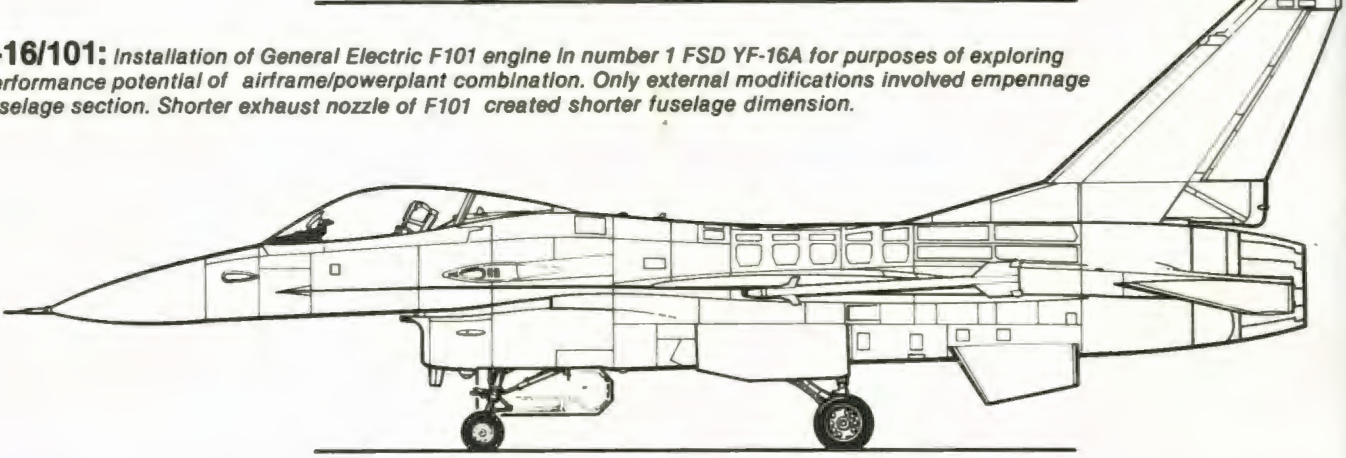
**YF-16A/AFTI:** *Most recent major F-16 modification. Utilizes the number 7 FSD YF-16A, the canards from the YF-16/CCV, and an advanced technology control system. Major external changes include canards, addition of large, faired, dorsal spine, and rear canopy fairing into spine.*



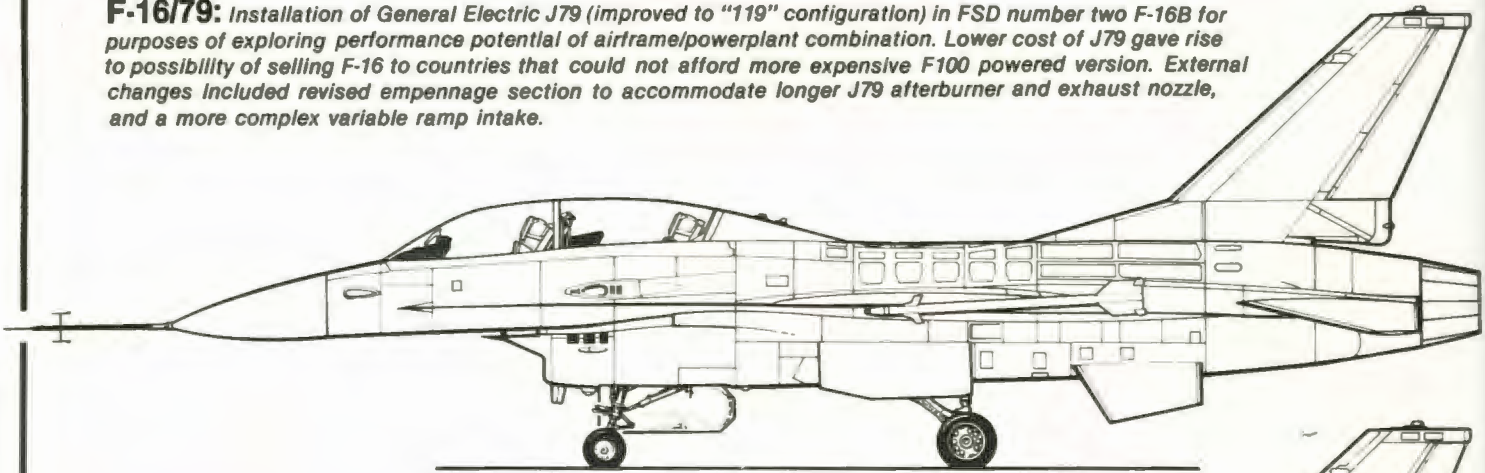
**F-16A/“Big Nose”:** *Completed in mock-up form only. Study conducted to explore feasibility of installing more powerful APG-65 radar system or 40" focal length HIAC camera. No external changes other than nose.*



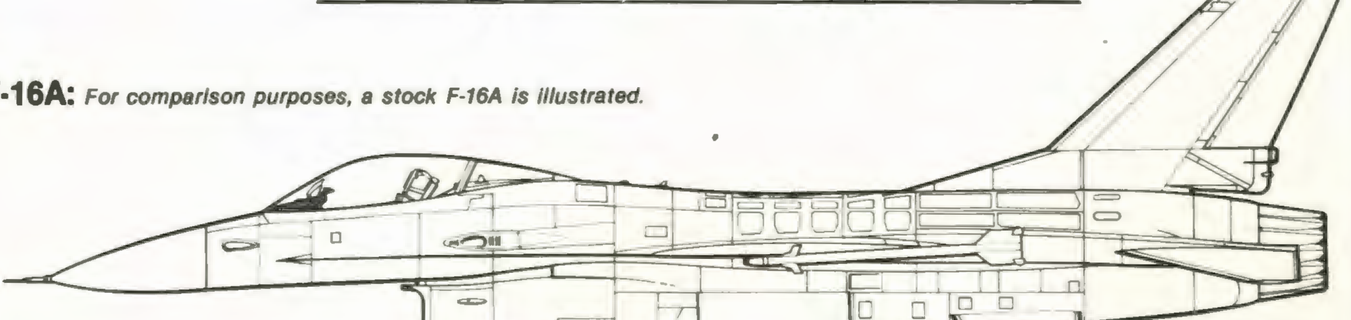
**F-16/101:** *Installation of General Electric F101 engine in number 1 FSD YF-16A for purposes of exploring performance potential of airframe/powerplant combination. Only external modifications involved empennage fuselage section. Shorter exhaust nozzle of F101 created shorter fuselage dimension.*



**F-16/79:** *Installation of General Electric J79 (improved to “119” configuration) in FSD number two F-16B for purposes of exploring performance potential of airframe/powerplant combination. Lower cost of J79 gave rise to possibility of selling F-16 to countries that could not afford more expensive F100 powered version. External changes included revised empennage section to accommodate longer J79 afterburner and exhaust nozzle, and a more complex variable ramp intake.*



**F-16A:** *For comparison purposes, a stock F-16A is illustrated.*

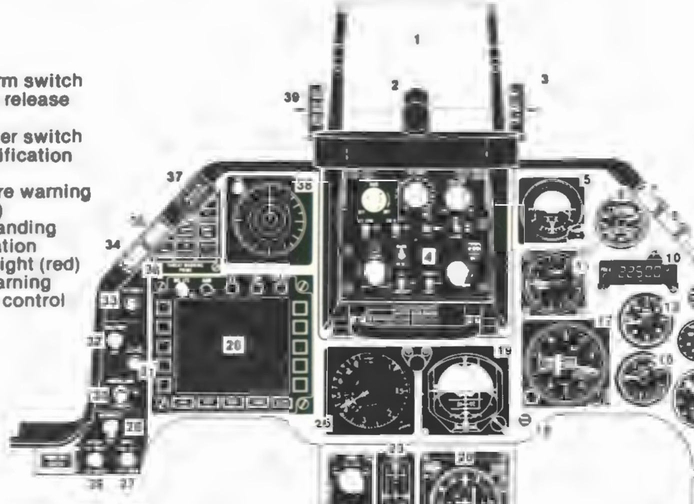


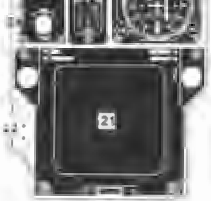
# F-16A COCKPIT ARRANGEMENT

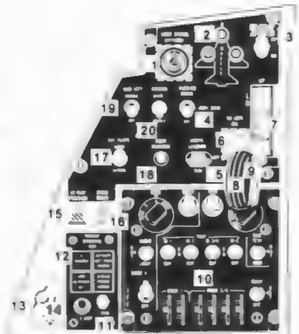
BLOCK IA NOV 1979

## INSTRUMENT PANEL

1. HUD combiner glass
2. Television sensor
3. Air refuel status/ NWS indicator
4. HUD control panel
5. Standby attitude indicator
6. Fuel flow indicator
7. Dual FC fail warning light (red)
8. Hyd/oil pressure warning light (red)
9. Canopy warning light (red)
10. UHF channel/ frequency indicator
11. Vertical velocity indicator
12. Engine oil pressure indicator
13. Tachometer
14. Nozzle position indicator
15. FTIT indicator
16. Fuel quantity indicator
17. Altimeter
18. Marker beacon light
19. Attitude director indicator
20. Horizontal situation indicator
21. Radar/electro-optical display
22. Rudder pedal adjustment knob
23. Angle of attack indicator
24. Instrument mode select panel
25. Air speed/Mach indicator
26. Stores control panel
27. Autopilot roll mode switch
28. Autopilot switch
29. Autopilot pitch mode switch
30. Master arm switch
31. Alternate release button
32. SMS power switch
33. IFF identification button
34. Engine fire warning light (red)
35. Takeoff/landing configuration warning light (red)
36. Threat warning indicator control unit
37. Master caution light (amber)
38. Threat warning azimuth indicator
39. Angle of attack indexer

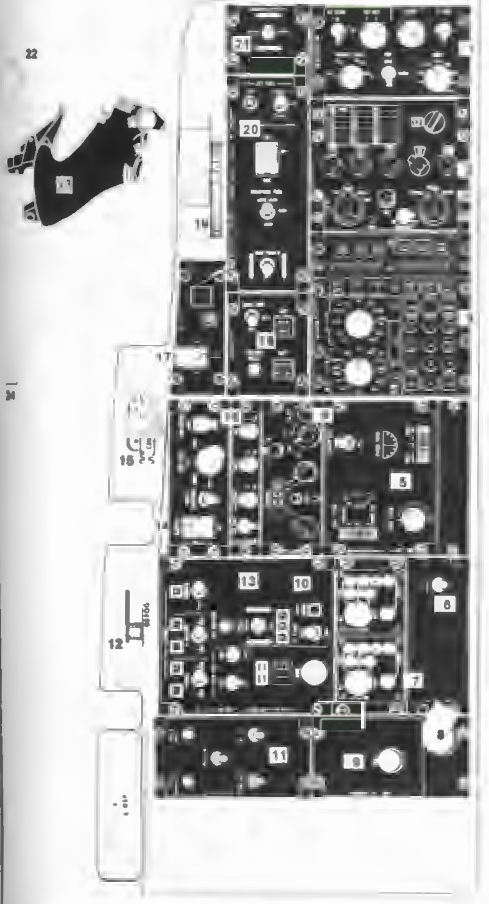






## LEFT CONSOLE

1. Radar control panel
2. UHF radio control panel
3. Fire control/ navigation panel
4. TACAN control panel
5. Flight control manual trim panel
6. Video select switch
7. ECM pod control panel
8. Anti-g suit hose connection
9. Anti-g test panel
10. Stick control select switch
11. Test switch panel
12. Defog control lever
13. Flight control panel
14. Fuel control panel
15. Canopy jettison panel
16. Communications control panel
17. EPU control panel
18. Electrical control panel
19. Throttle friction control
20. Engine and jet start control panel
21. Manual pitch over-ride switch
22. Chaff/flare dispenser button
23. Throttle
24. Reduced idle thrust switch (inoperable)

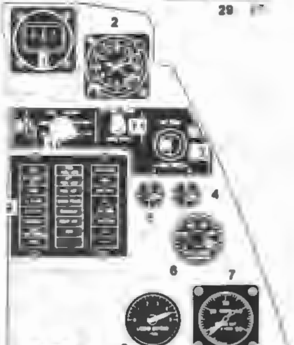


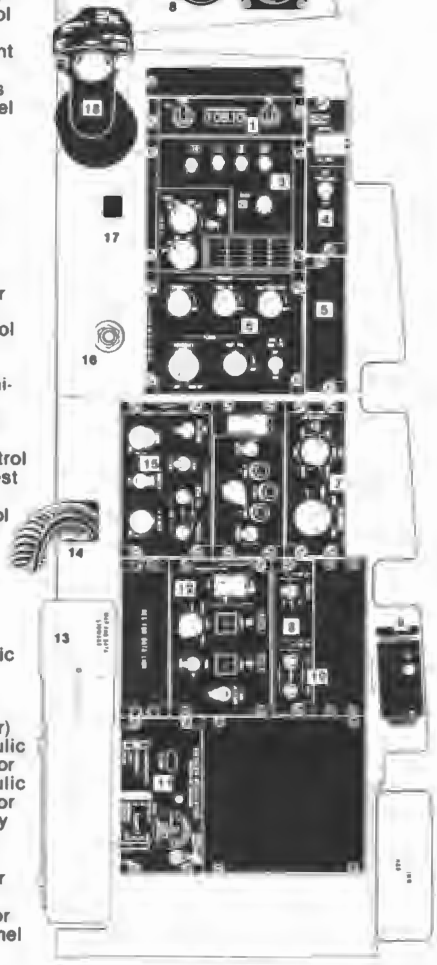
## RIGHT CONSOLE (TYPICAL)

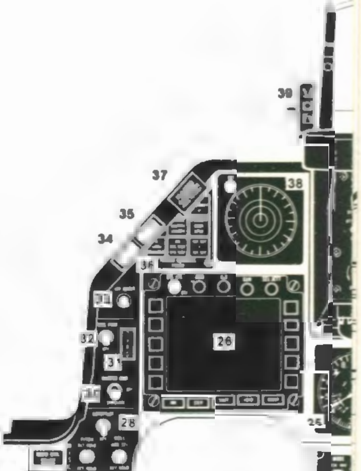
1. ILS control panel
2. Nuclear consent switch (guarded)
3. VHF radio control panel
4. Suit pressure vent switch
5. Communications take control panel
6. Interior lighting control panel
7. Air conditioning control panel
8. Engine anti-ice switch
9. Utility light
10. Antenna select panel
11. Oxygen regulator panel
12. Chaff/flare control panel
13. Map case
14. Oxygen/communi-cations hookup
15. Exterior lighting control panel
16. Backup fuel control switch ground test button
17. NWS take control button/indicator
18. Side stick

## RIGHT AUXILIARY CONSOLE

1. Standby magnetic compass
2. Clock
3. Oxygen flow indicator (blinker)
4. System B hydraulic pressure indicator
5. System A hydraulic pressure indicator
6. EPU fuel quantity indicator
7. Cabin pressure altitude indicator
8. Liquid oxygen quantity indicator
9. Caution light panel
10. Fuel quantity selector knob
11. External fuel transfer switch

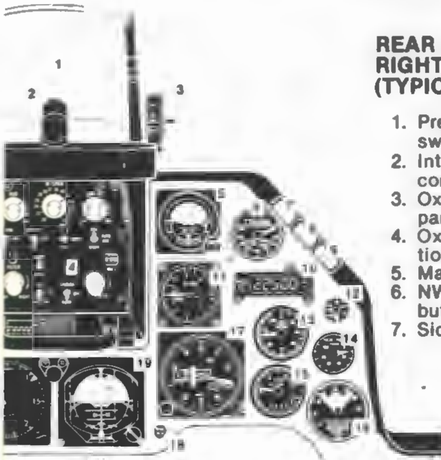






LEFT A CONSC

1. Em ett co
2. Wh gre
3. Arr swi
4. Par ant
5. Lar igh
6. Lar har ele
7. Lar har per
8. Lar pos ligh
9. Lar
10. IFF
11. Thr aux inte knc
12. Thr aux cor
13. Lar sel but
14. Aut anc dov har
15. Lea pos
16. Spe pos
17. Aut anc swi
18. Lar wa sile
19. Gro ena
20. Bra swi

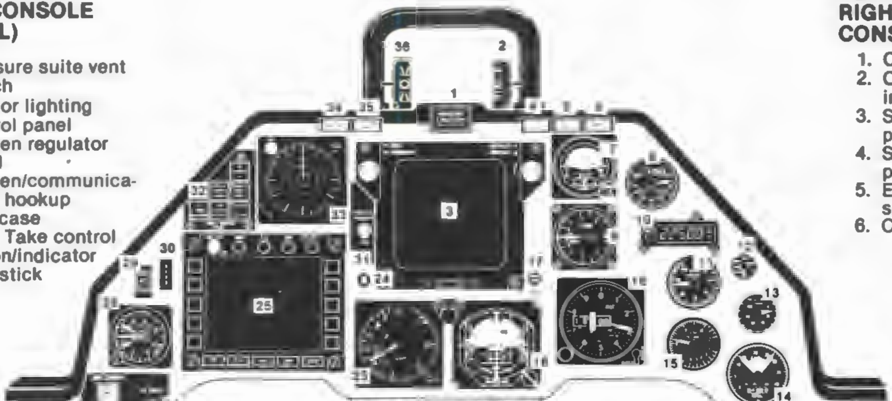


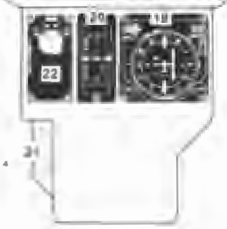
### REAR COCKPIT RIGHT CONSOLE (TYPICAL)

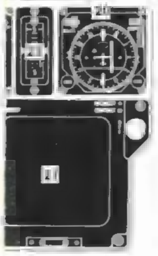
1. Pressure suite vent switch
2. Interior lighting control panel
3. Oxygen regulator panel
4. Oxygen/communications hookup
5. Map case
6. NWS Take control button/indicator
7. Side stick

### REAR COCKPIT RIGHT AUXILIARY CONSOLE

1. Clock
2. Oxygen flow indicator
3. System B hydraulic pressure indicator
4. System A hydraulic pressure indicator
5. Ejection mode select handle
6. Caution light panel

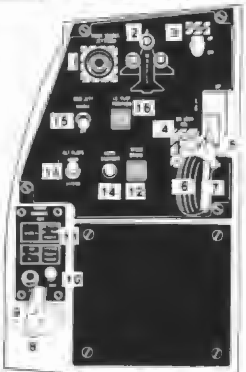


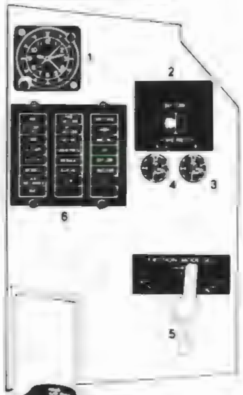




### REAR COCKPIT LEFT CONSOLE

1. Communications take-control panel
2. ILS control panel
3. TACAN control panel
4. UHF radio control panel
5. Anti-g suit hose connection
6. Anti-g test button
7. Malfunction and indicator lights test button
8. Canopy jettison handle
9. Backup fuel control switch





WD STATION

AFT STATION

UXILIARY
LE
ergency stores
ison button
vered)
eels down lights
een)
esting hook
tch (lever-lock)
king brake/
i-skid switch
ding/taxi
it switch
ding gear
dle downlock
ase button
ding gear
dle down
mission button
ding gear
ition warning
it (red)
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control panel
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ector valve reset
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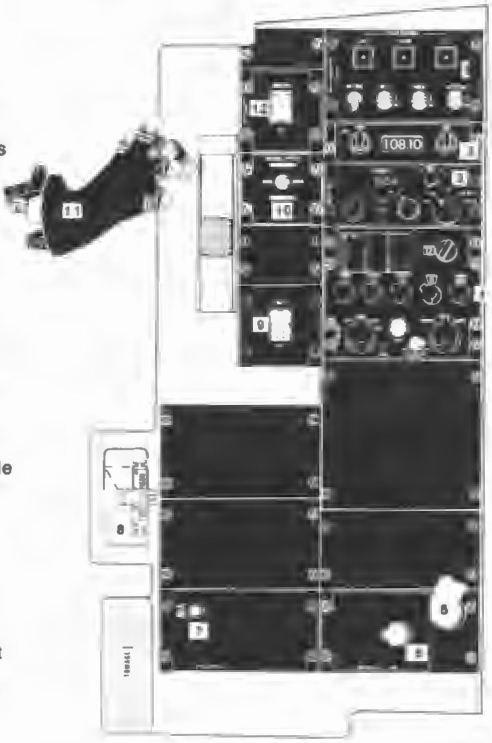


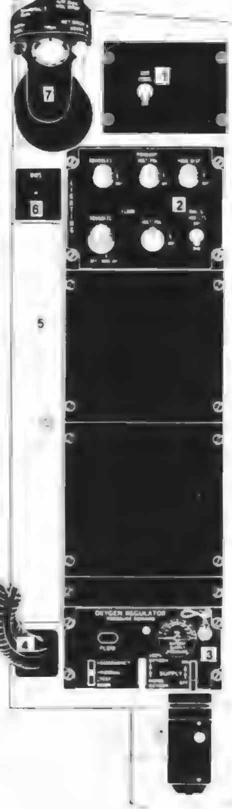
10. Manual pitch override switch
11. Throttle
12. Fuel master switch

### REAR COCKPIT INSTRUMENT PANEL

1. Master caution light (amber)
2. Air refuel status/NWS indicator
3. Radar/EO display
4. Dual FC fail warning light (red)
5. Hyd/oil pressure warning light (red)
6. Canopy warning light (red)
7. Standby attitude indicator
8. Fuel flow indicator
9. Vertical velocity indicator
10. UHF channel/frequency indicator
11. Tachometer
12. Engine oil pressure indicator
13. Nozzle position indicator
14. Fuel quantity indicator
15. FTIT indicator
16. Altimeter
17. Marker beacon light
18. Attitude director indicator
19. Horizontal situation indicator
20. Angle of attack indicator
21. Rudder pedal adjustment knob
22. Instrument mode select panel
23. Air speed/Mach indicator
24. Reduced idle thrust indicator (inoperable)
25. Stores control panel
26. IFF ident button
27. Armament consent switch
28. Accelerometer
29. Stick selector indicator
30. Stick override light
31. Video select switch
32. Threat warning indicator control unit
33. Threat warning azimuth indicator
34. Engine fire warning light (red)
35. Takeoff/landing configuration warning light (red)
36. Angle of attack indexer

### REAR COCKPIT LEFT AUXILIARY CONSOLE

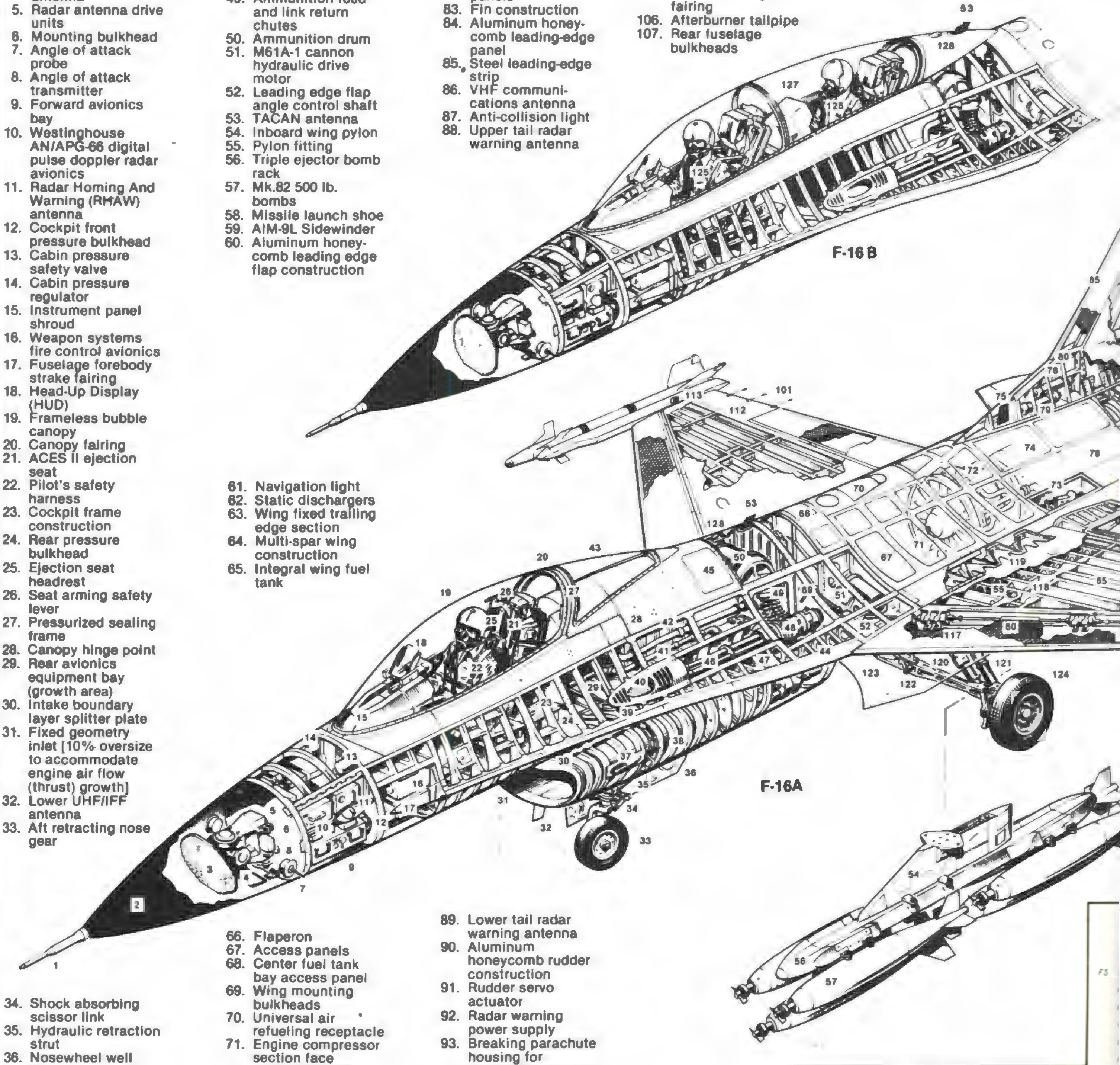
1. Emergency stores jettison button (covered)
2. Wheels down lights (green)
3. Arresting hook switch (lever-lock)
4. Landing gear handle downlock release button
5. Landing gear handle down permission button
6. Landing gear position warning light (red)
7. Landing gear handle
8. Automatic landing and takeoff gear down actuation handle
9. Landing gear selector valve reset button
10. Threat warning auxiliary legend intensity control knob
11. Threat warning auxiliary indicator/control knob
12. Speed brake position indicator
13. Automatic landing and takeoff flaps switch (lever-lock)
14. Landing gear warning horn silencer button
15. Ground jettison enable switch (lever-lock)
16. Leading edge flap position indicator

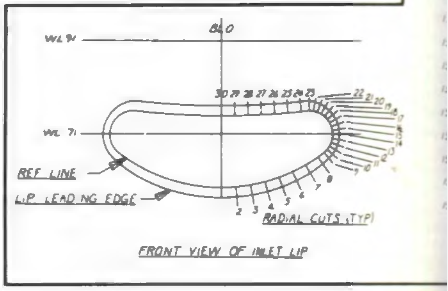


## GENERAL DYNAMICS F-16 CUTAWAY KEY:
## (Cutaway drawn 4-24-81 by Robert Cunningham of General Dynamics)

MAJOR SUBASSEMBLIES AN

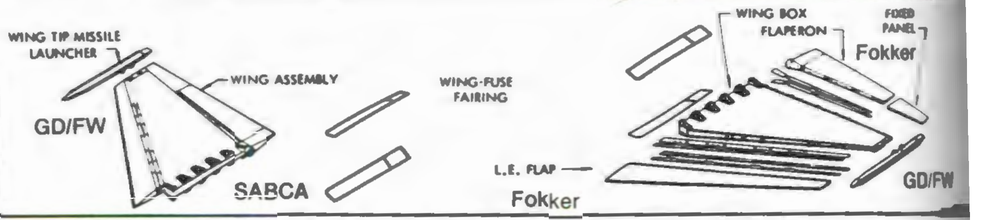
1. Air data probe
2. Dielectric nose radome
3. Planar radar antenna
4. ILS glideslope antenna
5. Radar antenna drive units
6. Mounting bulkhead
7. Angle of attack probe
8. Angle of attack transmitter
9. Forward avionics bay
10. Westinghouse AN/APG-66 digital pulse doppler radar avionics
11. Radar Homing And Warning (RHAW) antenna
12. Cockpit front pressure bulkhead
13. Cabin pressure safety valve
14. Cabin pressure regulator
15. Instrument panel shroud
16. Weapon systems fire control avionics
17. Fuselage forebody strake fairing
18. Head-Up Display (HUD)
19. Frameless bubble canopy
20. Canopy fairing
21. ACES II ejection seat
22. Pilot's safety harness
23. Cockpit frame construction
24. Rear pressure bulkhead
25. Ejection seat headrest
26. Seat arming safety lever
27. Pressurized sealing frame
28. Canopy hinge point
29. Rear avionics equipment bay (growth area)
30. Intake boundary layer splitter plate
31. Fixed geometry inlet [10% oversize to accommodate engine air flow (thrust) growth]
32. Lower UHF/IFF antenna
33. Aft retracting nose gear
34. Shock absorbing scissor link
35. Hydraulic retraction strut
36. Nosewheel well door
37. Forward position light
38. Intake trunking
39. Gun bay cooling air louvers
40. Gun gas suppression port
41. Air conditioning system plumbing
42. Forward fuselage fuel tank
43. Aft canopy glazing
44. Forebody blended wing root
45. Fuel tank bay access panel
46. M61A-1 rotary cannon barrels
47. Forebody frame construction
48. M61A-1 rotary cannon
49. Ammunition feed and link return chutes
50. Ammunition drum
51. M61A-1 cannon hydraulic drive motor
52. Leading edge flap angle control shaft
53. TACAN antenna
54. Inboard wing pylon
55. Pylon fitting
56. Triple ejector bomb rack
57. Mk.82 500 lb. bombs
58. Missile launch shoe
59. AIM-9L Sidewinder
60. Aluminum honeycomb leading edge flap construction
61. Navigation light
62. Static dischargers
63. Wing fixed trailing edge section
64. Multi-spar wing construction
65. Integral wing fuel tank
66. Flaperon
67. Access panels
68. Center fuel tank bay access panel
69. Wing mounting bulkheads
70. Universal air refueling receptacle
71. Engine compressor section face
72. Pratt & Whitney F100-PW-100 afterburning turbofan engine
73. Flaperon servo actuator
74. Rear integral fuel tank
75. Upper UHF/IFF antenna
76. Fuselage skin plating
77. Side body fairing
78. Fin root fillet
79. Flight control system hydraulic accumulators
80. Anti-collision light power supply unit
81. Increased area horizontal slab stabilator
82. Graphite-epoxy skin panels
83. Fin construction
84. Aluminum honeycomb leading-edge panel
85. Steel leading-edge strip
86. VHF communications antenna
87. Anti-collision light
88. Upper tail radar warning antenna
89. Lower tail radar warning antenna
90. Aluminum honeycomb rudder construction
91. Rudder servo actuator
92. Radar warning power supply
93. Breaking parachute housing for Norwegian and late MSIP series aircraft only
94. Threat warning antennas for parachute housing
95. Navigation light for parachute housing
96. Tail navigation light
97. Fully variable exhaust nozzle
98. Nozzle flaps
99. Split trailing edge airbrakes, upper and lower surfaces
100. Airbrake hydraulic jack
101. Static dischargers
102. Corrugated aluminum substructure
103. Hinge pivot fitting
104. Tailplane servo actuator
105. Nozzle sealing fairing
106. Afterburner tailpipe
107. Rear fuselage bulkheads
108. Chaff dispenser (ejects chaff downward)
109. Runway arrester hook
110. Flaperon hinges



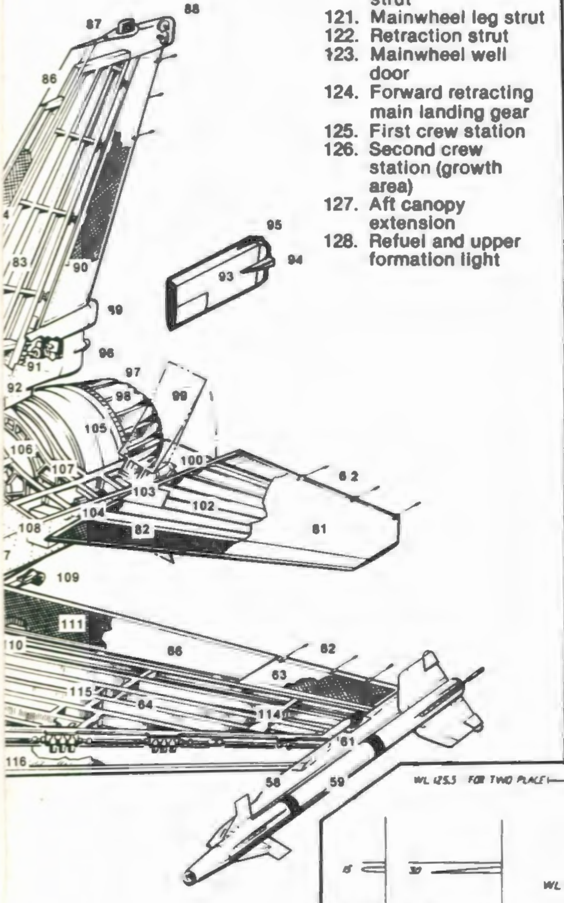


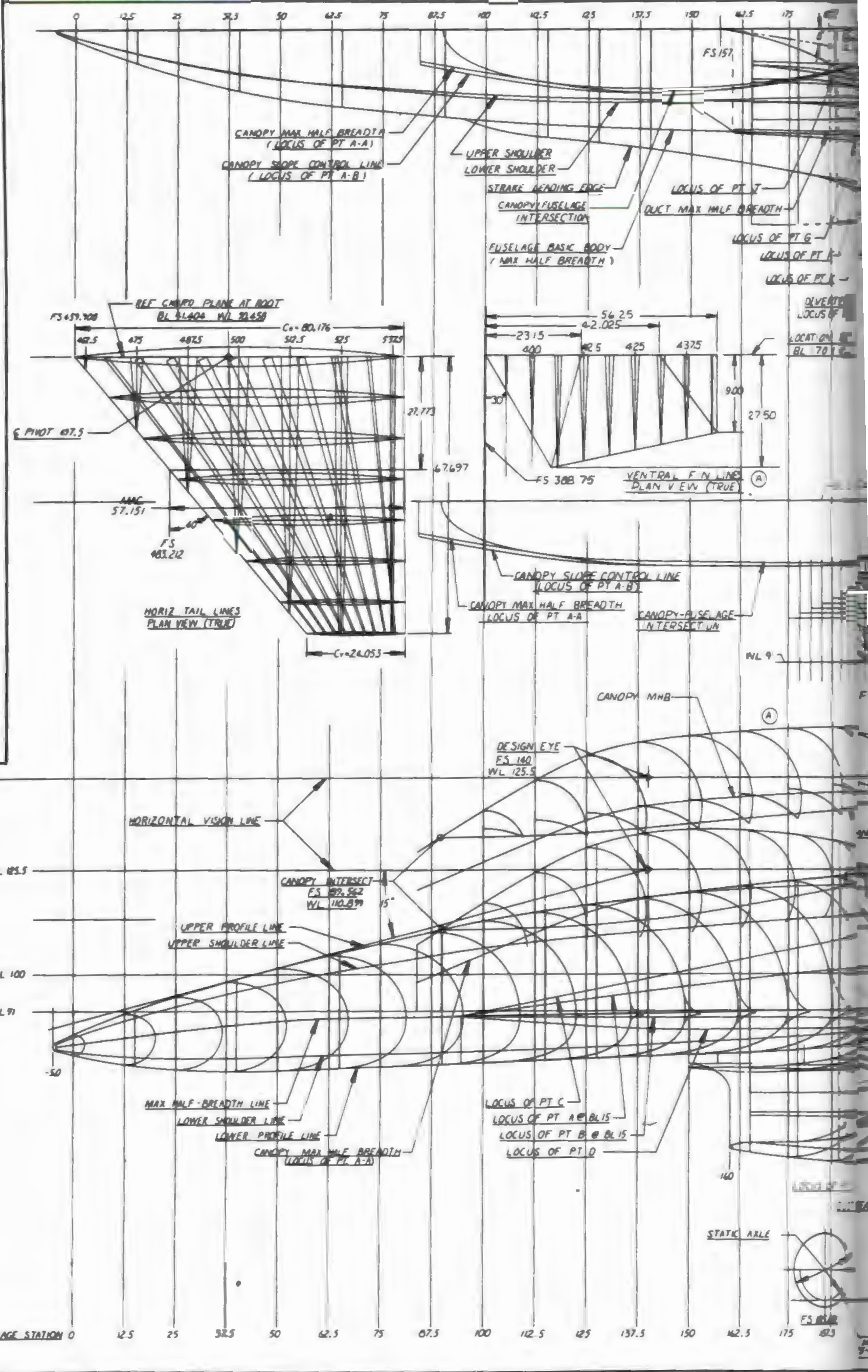
FRONT VIEW OF INLET LIP

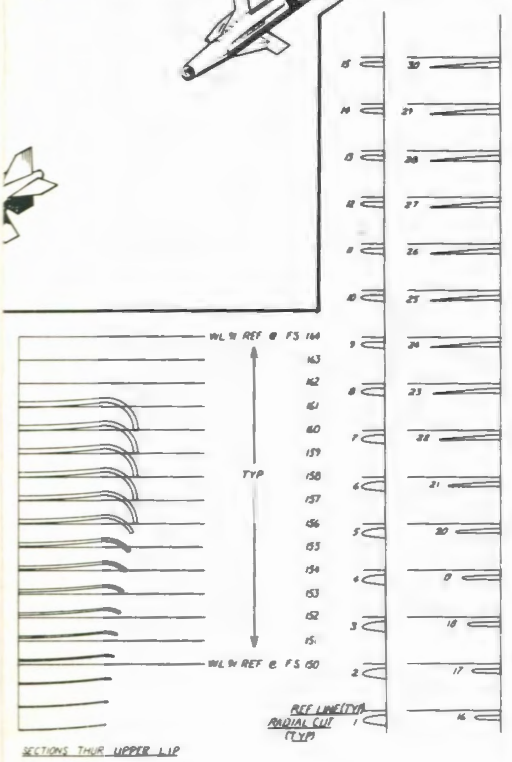
## F-16 CO-PRODUCTION COMPONENT BREAKDOWN:

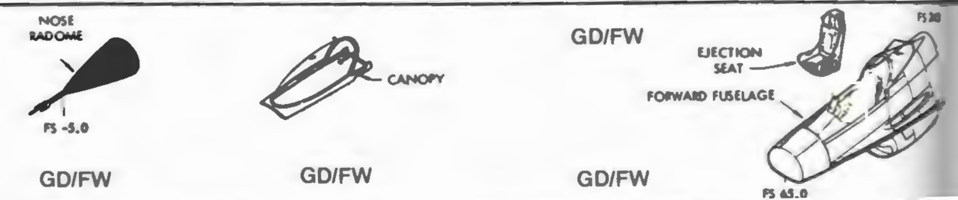


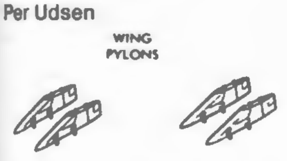
111. Aluminum honeycomb flaperon construction
112. Fixed trailing edge section
113. Navigation light
114. Outboard pylon support rib
115. Center pylon support rib
116. Leading-edge maneuvering flap
117. Leading-edge flap rotary actuators
118. Inboard pylon fitting
119. Wing attachment fishplates
120. Main landing gear shock absorber strut
121. Mainwheel leg strut
122. Retraction strut
123. Mainwheel well door
124. Forward retracting main landing gear
125. First crew station
126. Second crew station (growth area)
127. Aft canopy extension
128. Refuel and upper formation light

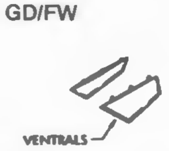


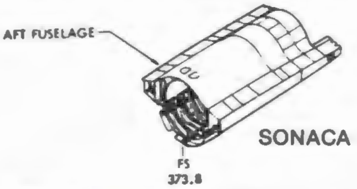


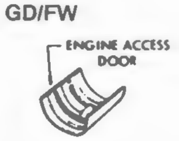


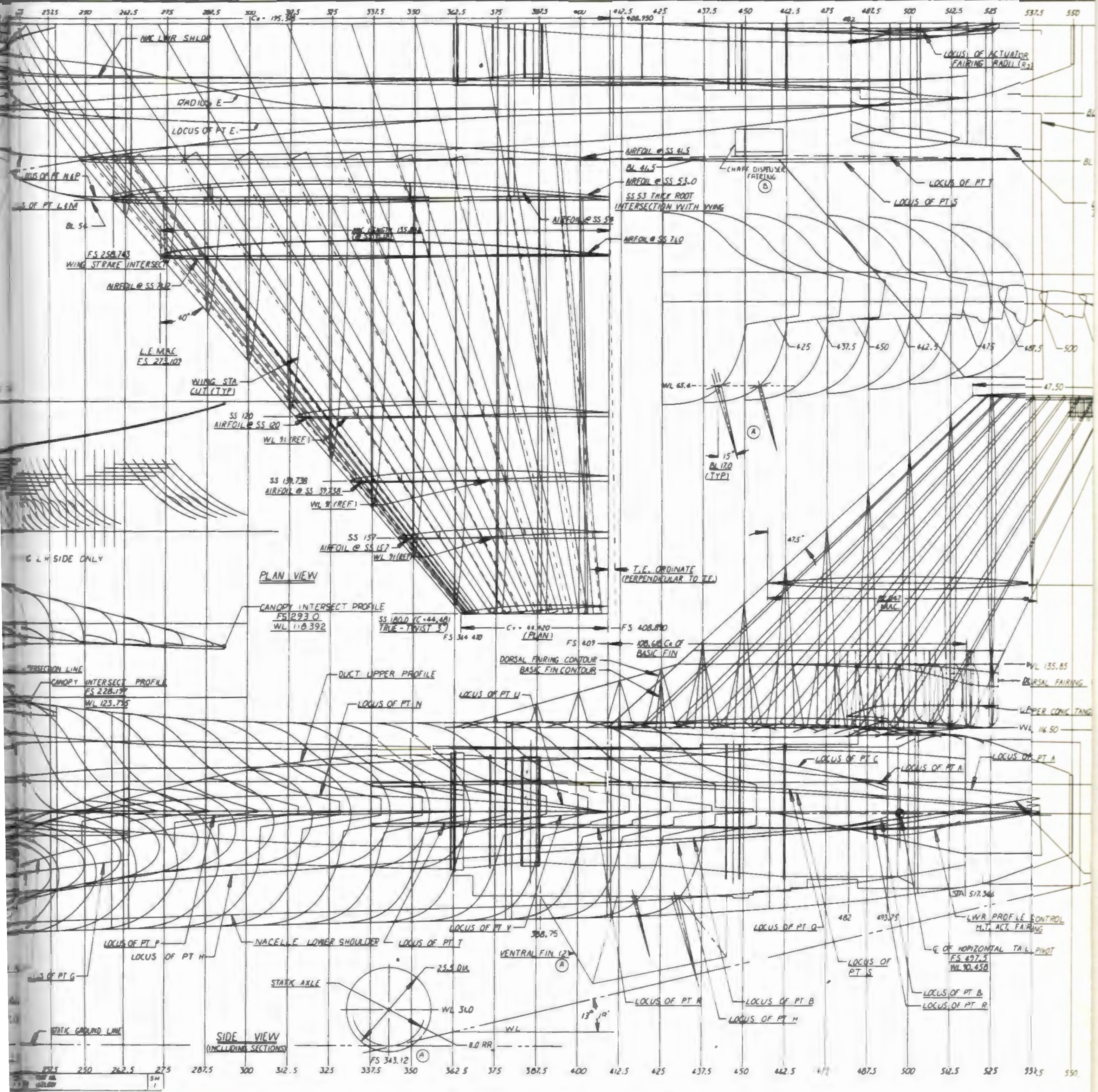


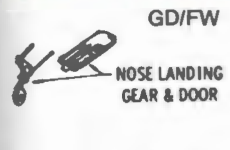

Per Udsen
WING PYLONS

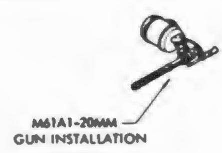

GD/FW
VENTRALS

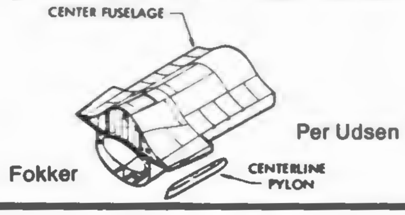

AFT FUSELAGE
FS 373.8
SONACA

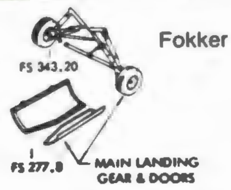

GD/FW
ENGINE ACCESS DOOR

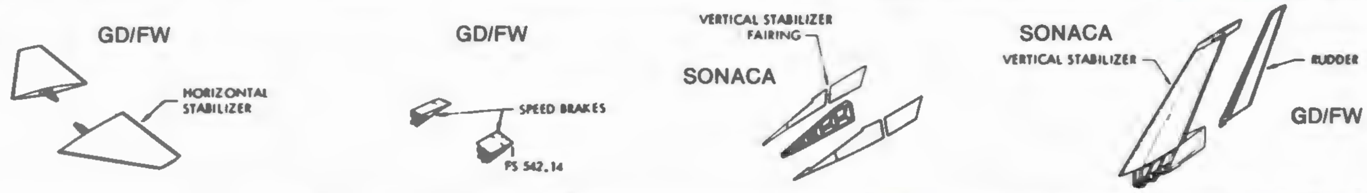

237.5 250 262.5 275 287.5 300 312.5 325 337.5 350 362.5 375 387.5 400 412.5 425 437.5 450 462.5 475 487.5 500 512.5 525 537.5 550
Co = 195.33
408.950
NAC LWR SHLDR
RADIUS E
LOCUS OF PT E
LOCUS OF ACTUATOR FAIRING RADII
AIRFOIL @ SS 41.5
BL 41.5
AIRFOIL @ SS 53.0
SS 53 TRK ROOT INTERSECTION WITH WING
CHAFF DISPENSER FAIRING
LOCUS OF PT T
LOCUS OF PT S
LOCUS OF PT M&P
LOCUS OF PT L/M
BL 54
AIRFOIL @ SS 58
AIRFOIL @ SS 76.0
FS 258.743
WING STRAKE INTERSECT
AIRFOIL @ SS 76.0
40°
L.E. MAC
FS 273.109
WING STA CUT (TYP)
425 437.5 450 462.5 475 487.5 500
WL 65.4
47.50
SS 120
AIRFOIL @ SS 120
WL 91 (REF)
15°
BL 17.0 (TYP)
SS 139.738
AIRFOIL @ SS 139.738
WL 91 (REF)
SS 157
AIRFOIL @ SS 157
WL 91 (REF)
47.5°
LH SIDE ONLY
PLAN VIEW
T.E. ORDINATE (PERPENDICULAR TO T.E.)
CANOPY INTERSECT PROFILE
FS 293.0
WL 118.392
SS 180.0 (C = 44.48)
TRUE - TWIST 3°
FS 364.420
Ct = 44.420 (PLAN)
FS 408.890
FS 409
108.68 Co OF BASIC FIN
MAC
DORSAL FAIRING CONTOUR
BASIC FIN CONTOUR
WL 135.85
DORSAL FAIRING
UPPER CONIC TANG
WL 116.50
CANOPY INTERSECT PROFILE
FS 228.197
WL 123.795
DUCT UPPER PROFILE
LOCUS OF PT N
LOCUS OF PT U
LOCUS OF PT C
LOCUS OF PT A
LOCUS OF PT A
STA 517.366
LWR PROFILE CONTROL H.T. ACT. FAIRING
482
493.75
LOCUS OF PT Q
℄ OF HORIZONTAL TAIL PIVOT
FS 497.5
WL 90.458
LOCUS OF PT V
388.75
VENTRAL FIN (2) Ⓐ
LOCUS OF PT S
LOCUS OF PT P
LOCUS OF PT H
NACELLE LOWER SHOULDER
LOCUS OF PT T
LOCUS OF PT G
25.5 DIA
STATIC AXLE
WL 34.0
LOCUS OF PT R
LOCUS OF PT B
LOCUS OF PT B
LOCUS OF PT R
LOCUS OF PT H
13° 19'
STATIC GROUND LINE
SIDE VIEW (INCLUDING SECTIONS)
WL
8.0 RR
FS 343.12 Ⓐ
SH 1

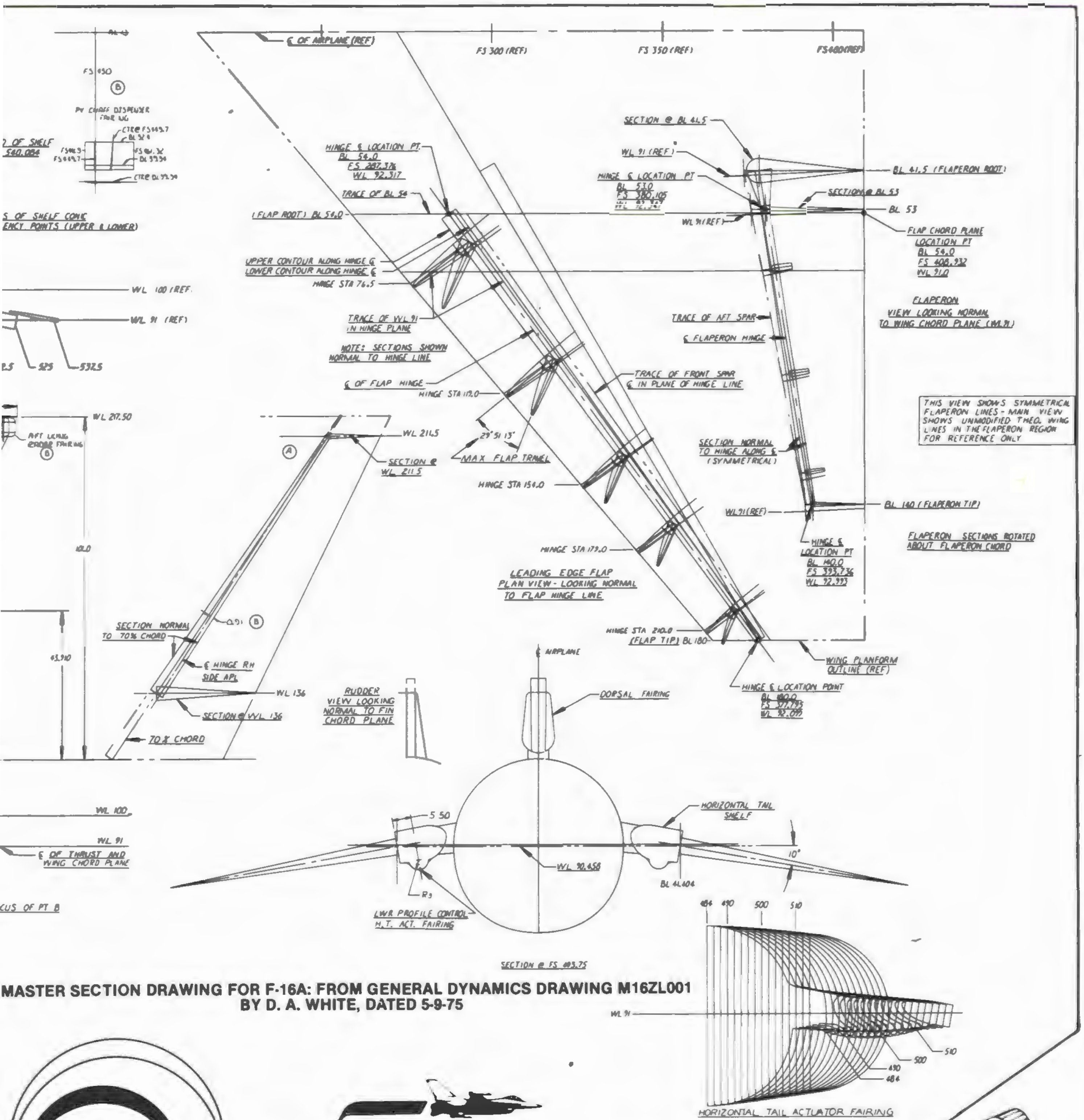

GD/FW
NOSE LANDING GEAR & DOOR
SONACA


M61A1-20MM GUN INSTALLATION
GD/FW


CENTER FUSELAGE
Per Udsen
Fokker
CENTERLINE PYLON

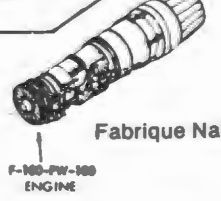

Fokker
FS 343.20
FS 277.8
MAIN LANDING GEAR & DOORS



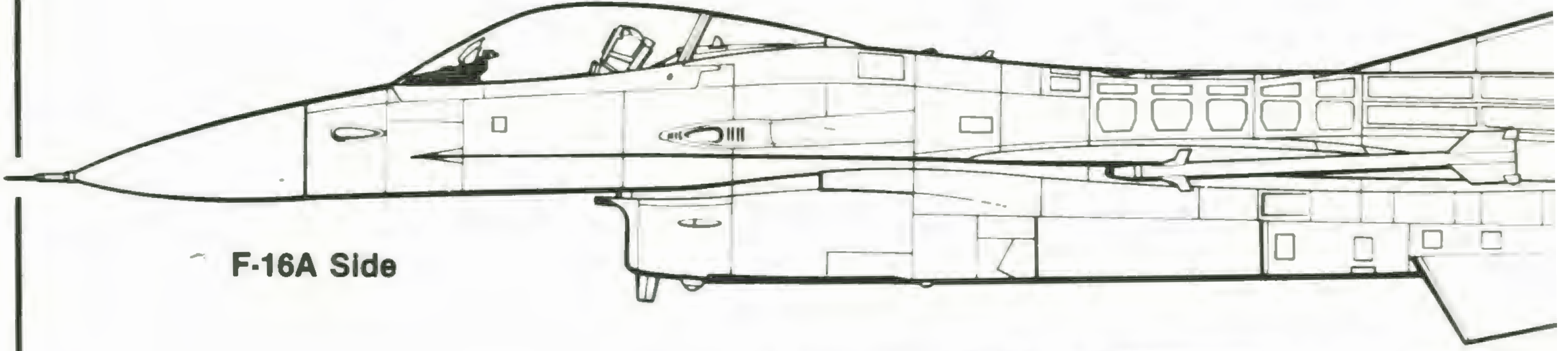


MASTER SECTION DRAWING FOR F-16A: FROM GENERAL DYNAMICS DRAWING M16ZL001 BY D. A. WHITE, DATED 5-9-75

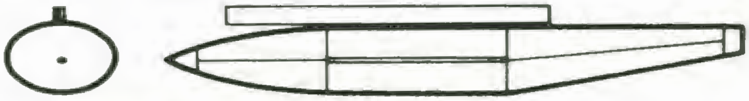
**F-16 Multirole Fighter**



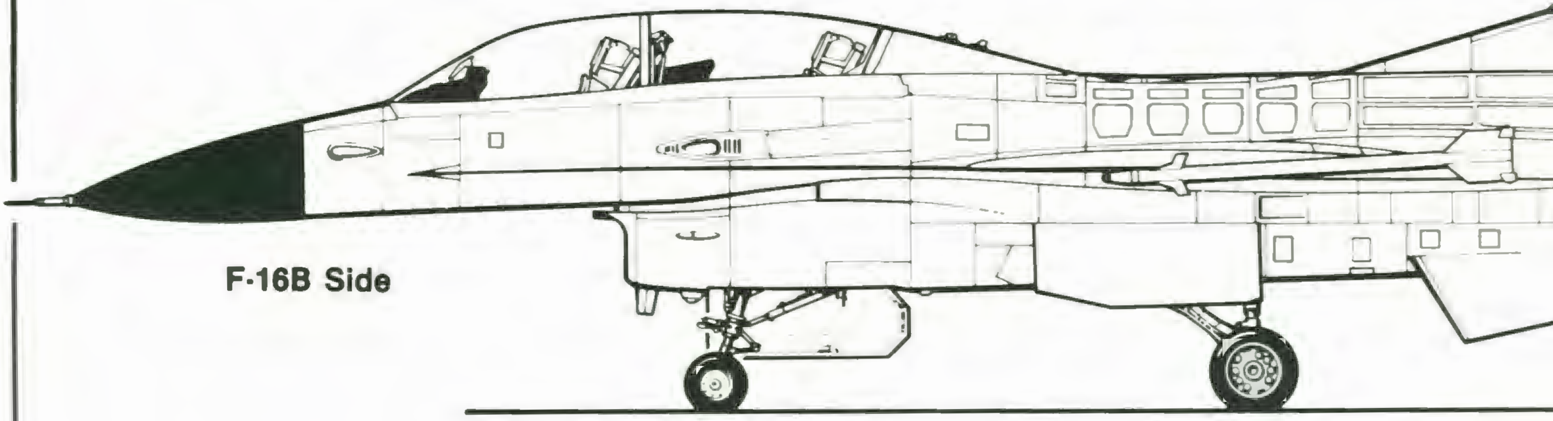
## F-16 Multiviews



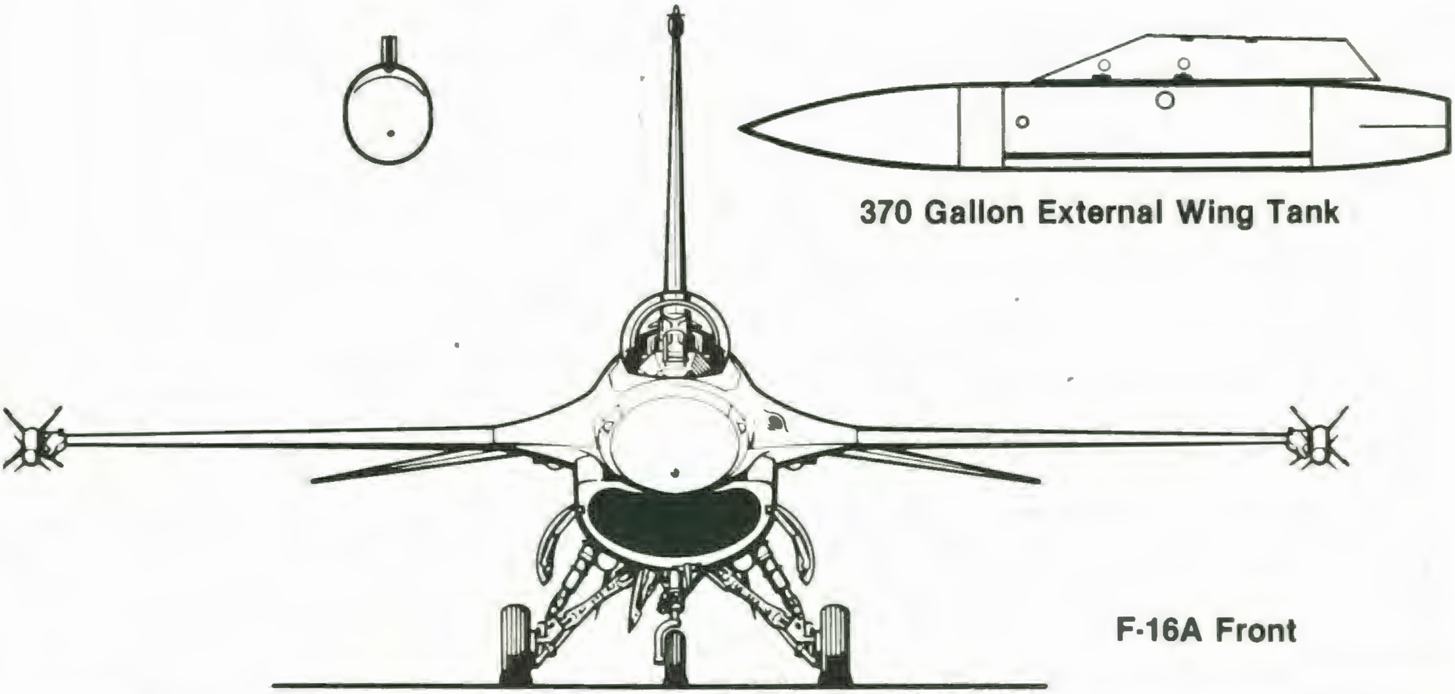
F-16A Side



300 Gallon Centerline Tank



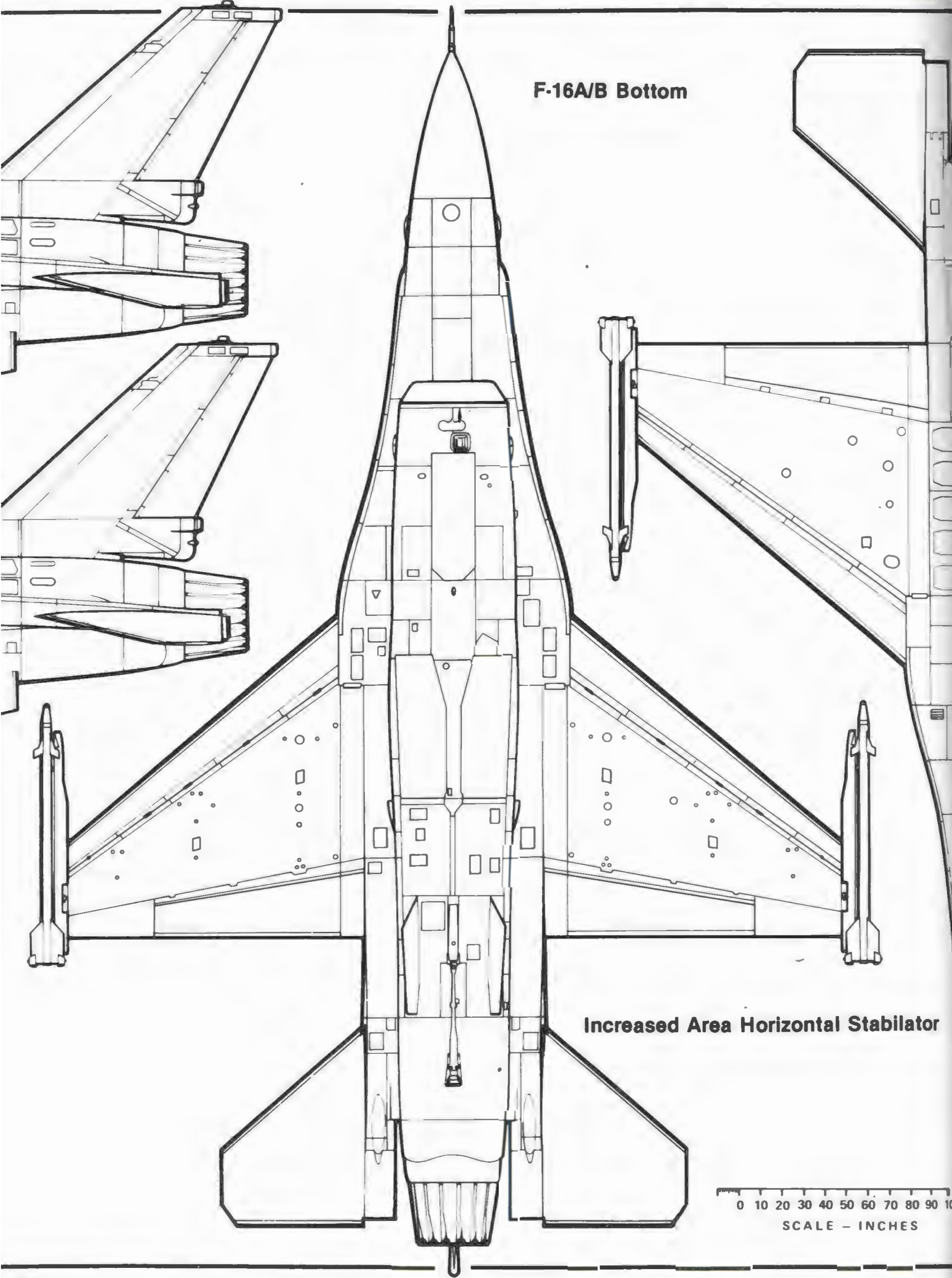
F-16B Side

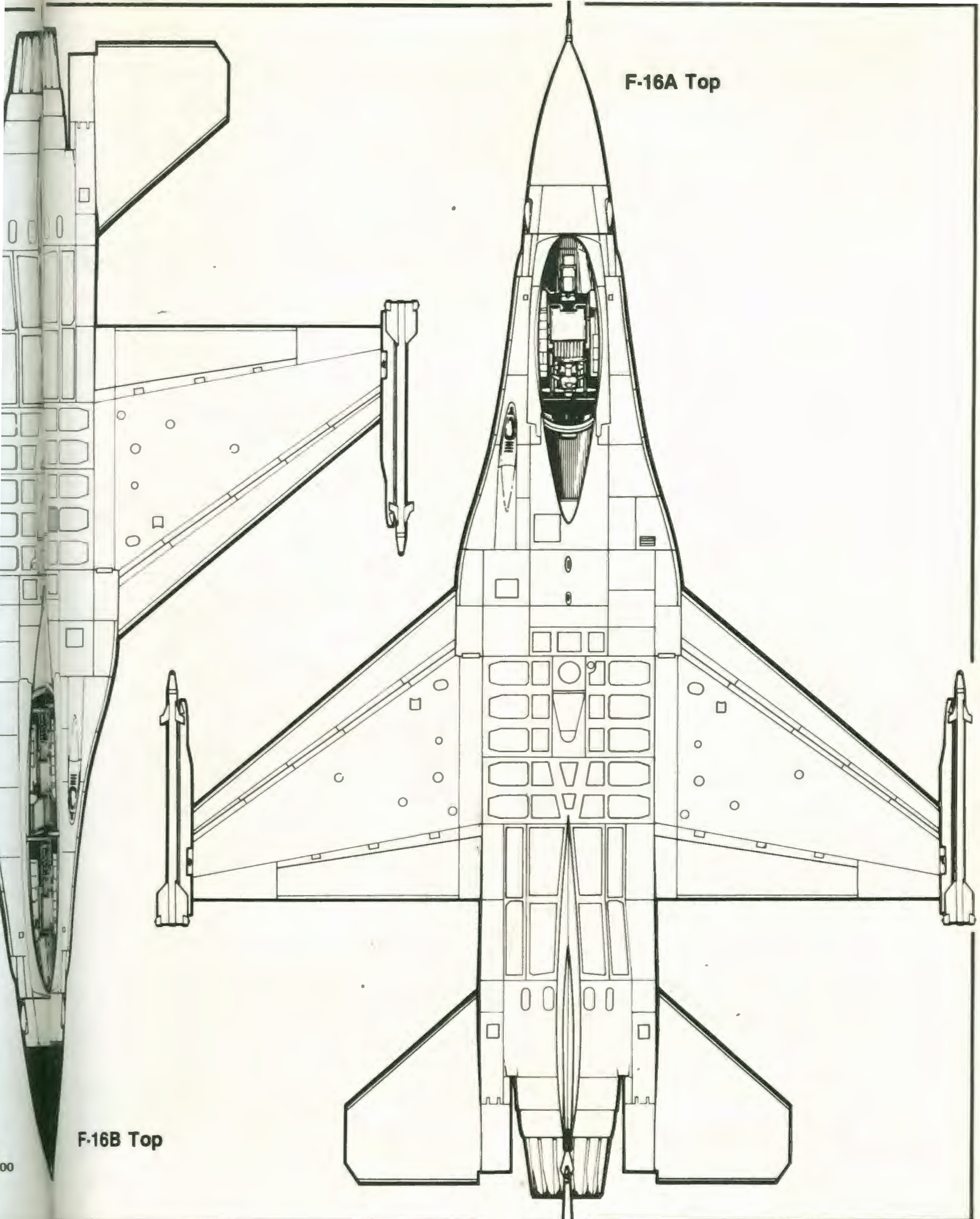


370 Gallon External Wing Tank

F-16A Front

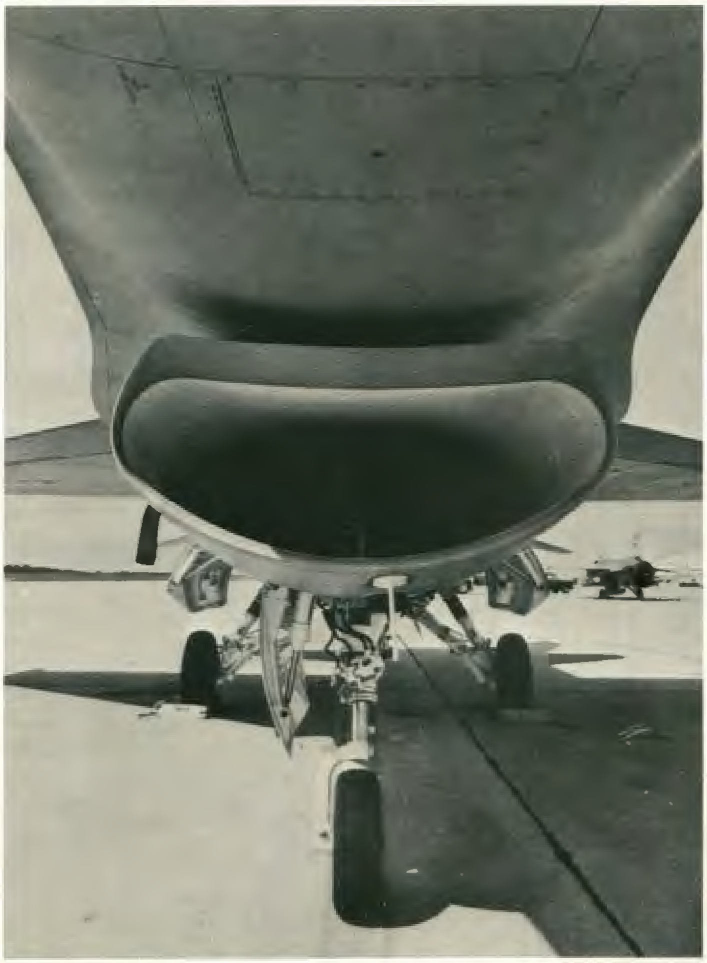
## F-16A/B Bottom

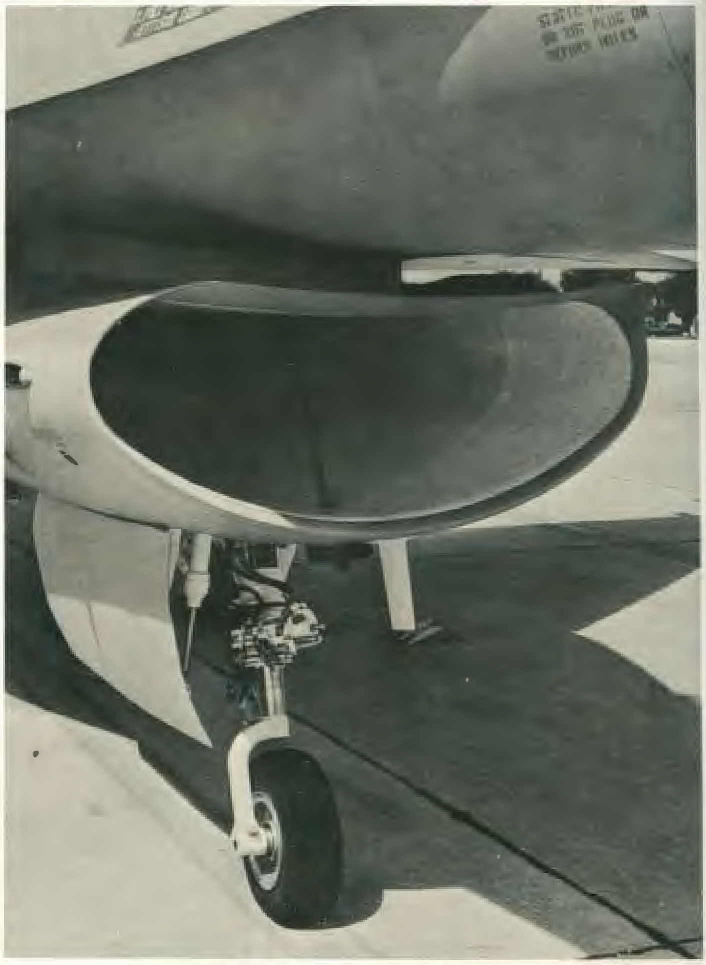



F-16A Top
F-16B Top
00

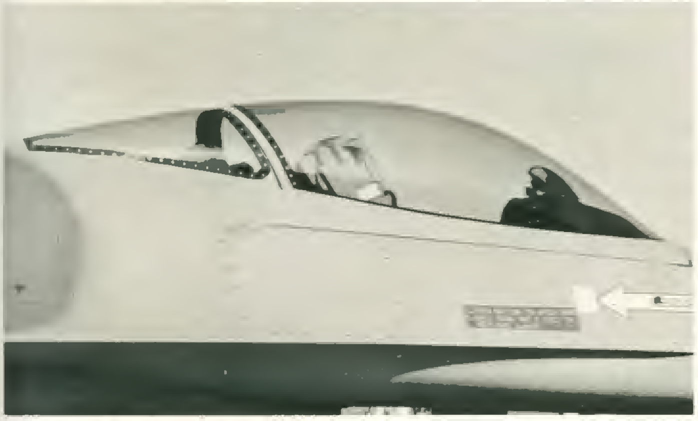
| SPECIFICATIONS: | F-16A | F-16B |
|---|---|---|
| Wingspan (including rails) | 31' 0" | 31' 0" |
| Wingspan (including missiles) | 32' 10" | 32' 10" |
| Wing aspect ratio | 3.0 | 3.0 |
| Wing taper ratio | 0.2275 | 0.2275 |
| Wing area (gross) | 300 sq. ft. | 300 sq. ft. |
| Flaperon area | 31.32 sq. ft. | 31.32 sq. ft. |
| Flaperon surface travel | 20-deg. up<br>20-deg. down | 20-deg. up<br>20-deg. down |
| Leading edge flap area | 36.71 sq. ft. | 36.71 sq. ft. |
| Leading edge flap travel | 0-deg. up<br>30-deg. down | 0-deg. up<br>30-deg. down |
| Wing dihedral | 0-deg. | 0-deg. |
| Wing incidence | 0-deg. | 0-deg. |
| Wing twist @ S.S. 54.0 | 0-deg. | 0-deg. |
| Wing twist @ S.S. 180.0 | 3-deg. | 3-deg. |
| Wing loading @ 22,000 lbs. | 73 lbs. sq. ft. | 73 lbs. sq. ft. |
| Wing loading @ 33,000 lbs. | 110 lbs. sq. ft. | 110 lbs. sq. ft. |
| Empty weight | 15,586 lbs. | 16,258 lbs. |
| Internal fuel load | 6,972 lbs. | 5,785 lbs. |
| Maximum external load | 20,450 lbs. | 20,450 lbs. |
| Maximum takeoff weight in air-to-air config. with no external tanks | 23,810 lbs. | 23,298 lbs. |
| Maximum gross takeoff weight | 35,400 lbs. | 35,400 lbs. |
| Length overall | 49' 5.9" | 49' 5.9" |
| Height overall | 16' 8.5" | 16' 8.5" |
| Tailplane span | 18' 6" | 18' 6" |
| Tailplane area | 49.0 sq. ft. | 49.0 sq. ft. |
| Tailplane aspect ratio | 2.598 | 2.598 |
| Tailplane taper ratio | 0.3 | 0.3 |
| Tailplane leading edge sweep | 40-deg. | 40-deg. |
| Tailplane dihedral | -10-deg. | -10-deg. |
| Tailplane airfoil at root | 6% biconvex | 6% biconvex |
| Tailplane airfoil at tip | 3.5% biconvex | 3.5% biconvex |
| Tailplane surface travel | 25-deg. up<br>25-deg. down | 25-deg. up<br>25-deg. down |

| SPECIFICATIONS: | F-16A | F-16B |
|---|---|---|
| Vertical tail area | 54.75 sq. ft. | 54.75 sq. ft. |
| Vertical tail aspect ratio | 1.294 | 1.294 |
| Vertical tail taper ratio | 0.437 | 0.437 |
| Vertical tail leading edge sweep | 47.5-deg. | 47.5-deg. |
| Vertical tail airfoil at root | 5.3% biconvex | 5.3% biconvex |
| Vertical tail airfoil at tip | 3.0% biconvex | 3.0% biconvex |
| Rudder area | 11.65 sq. ft. | 11.65 sq. ft. |
| Rudder surface travel | 30-deg. l/r | 30-deg. l/r |
| Ventral fin area | 8.03 sq. ft. | 8.03 sq. ft. |
| Ventral fin span | 27.5"<br>(23.356 theo.) | 27.5"<br>(23.356 theo.) |
| Ventral fin aspect ratio | .4718 theo. | .4718 theo. |
| Ventral fin taper ratio | .7603 theo. | .7603 theo. |
| Ventral fin leading edge sweep | 30-deg. | 30-deg. |
| Ventral fin dihedral (cant) | 15-deg. outbd. | 15-deg. outbd. |
| Ventral fin airfoil at root | 3.886% mod. wedge | 3.886% mod. wedge |
| Ventral fin airfoil at tip | constant .03R | constant .03R |
| Speed brake area (4 element clamshell) | 14.26 sq. ft.<br>3.565 sq. ft. ea. | 14.26 sq. ft.<br>3.565 sq. ft. ea. |
| Speed brake travel | 60-deg. up<br>60-deg. down | 60-deg. up<br>60-deg. down |
| Wheel track | 7' 9" | 7' 9" |
| Wheelbase | 13' 1.44" | 13' 1.44" |
| Main gear static rolling radius | 11.0" | 11.0" |
| Nose gear stroke | 10.0" | 10.0" |
| Nose gear static rolling radius | 7.5" | 7.5" |
| Thrust-to-weight ratio in clean condition | 1.1 to 1 | 1.1 to 1 |
| Maximum level flight speed @ 40,000' | Mach 2.1 | Mach 2.0 |
| Service ceiling | 50,000'+ | 50,000'+ |
| Radius of action | 575 miles+ | 500 miles+ |
| Ferry range with drop tanks | 2,450 miles+ | 2,350 miles+ |

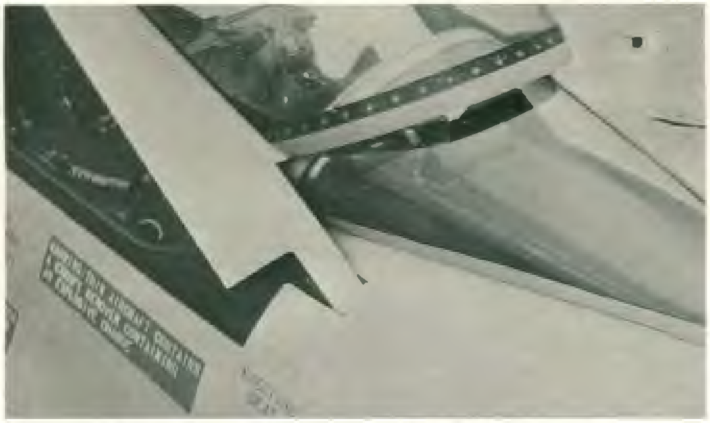

*Front view of under-fuselage-mounted intake details intake lip and boundary layer space. Aerofax*


*Separation strut is mounted inside intake lip for additional tunnel rigidity. This intake design was known as the "smiley" intake at General Dynamics. Aerofax*

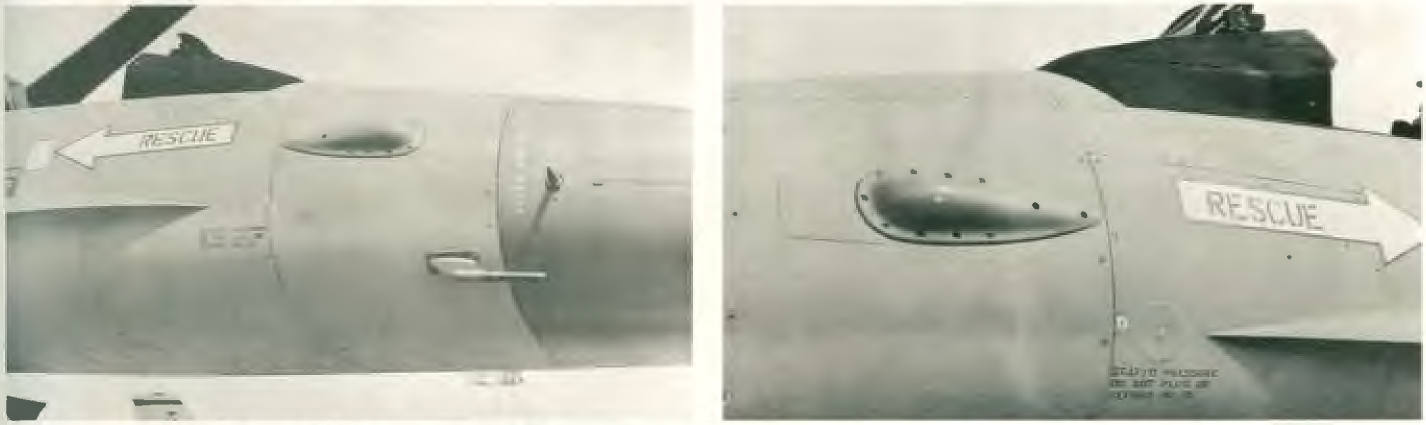
# Miscellaneous Details



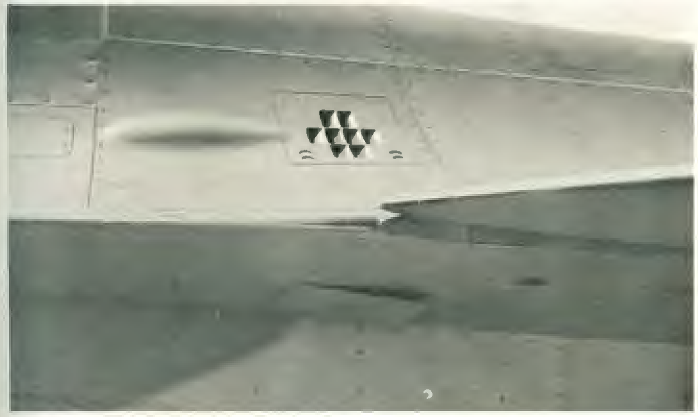
Canopy is essentially one-piece unit offering superb 360-degree vision for pilot. Aerofax



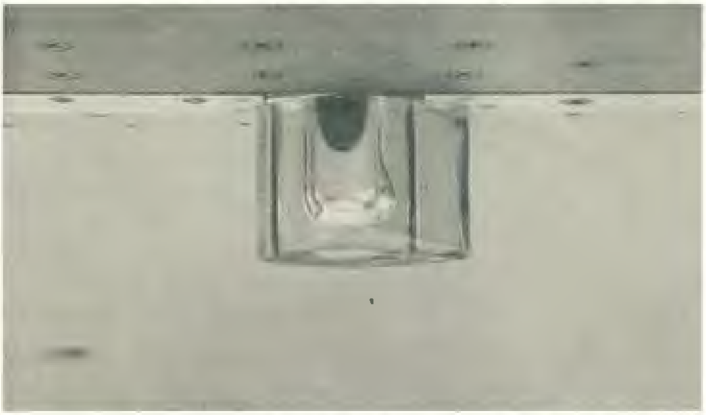
Canopy hinge points are located just behind ACES II ejection seat. Aerofax



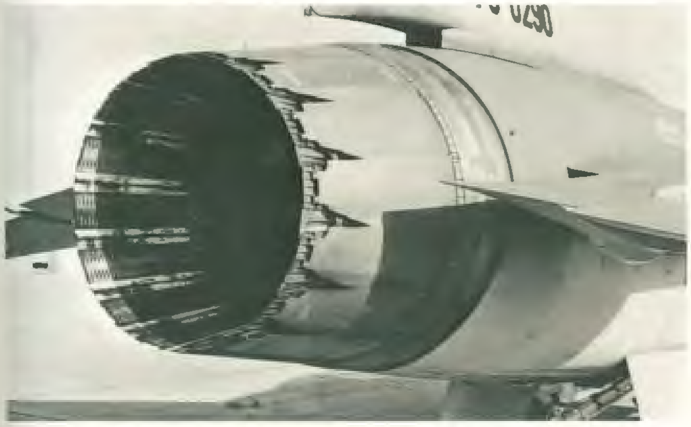
Nose section details show RHAW antennas and their small aerodynamic covers, the angle of attack probes, and a pitot sensor. Aerofax



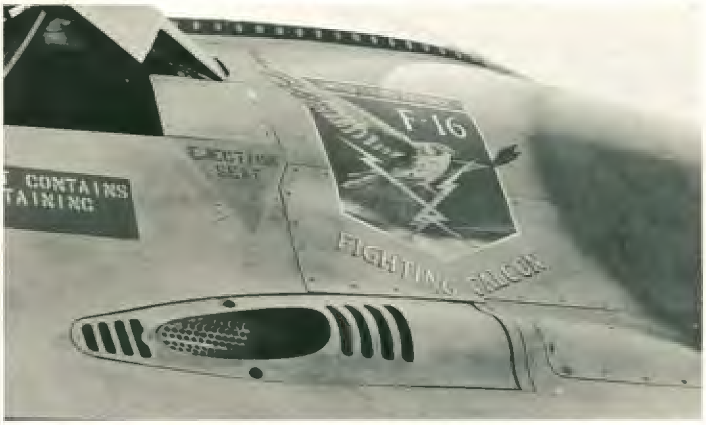
Gun gas ejector ports are located on left side of airplane only. Aerofax



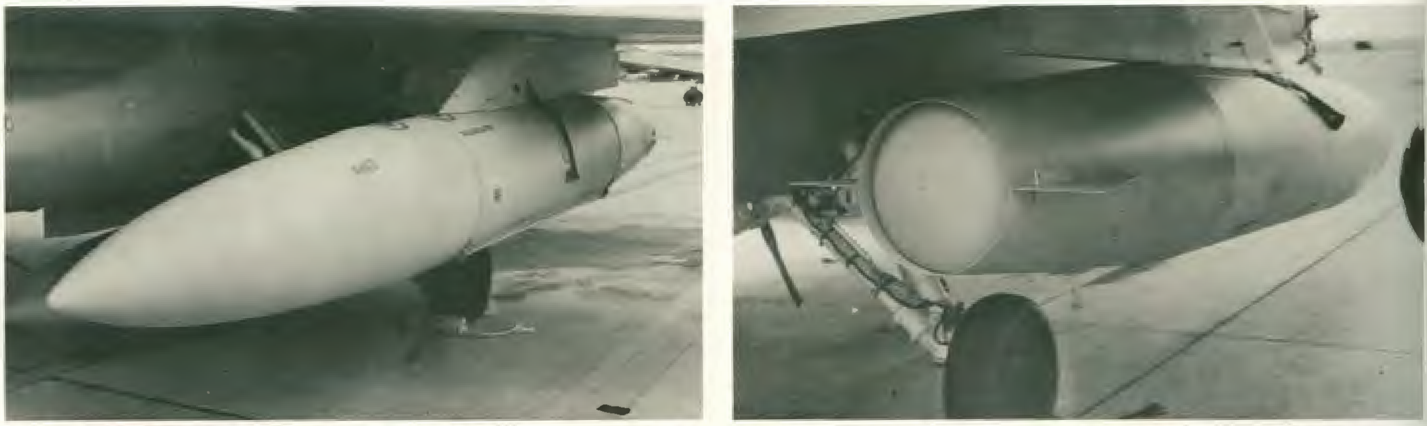
Wingtip position/formation lights are small and protrude from the top and bottom of each wing, just inside of the missile launch rails. Aerofax



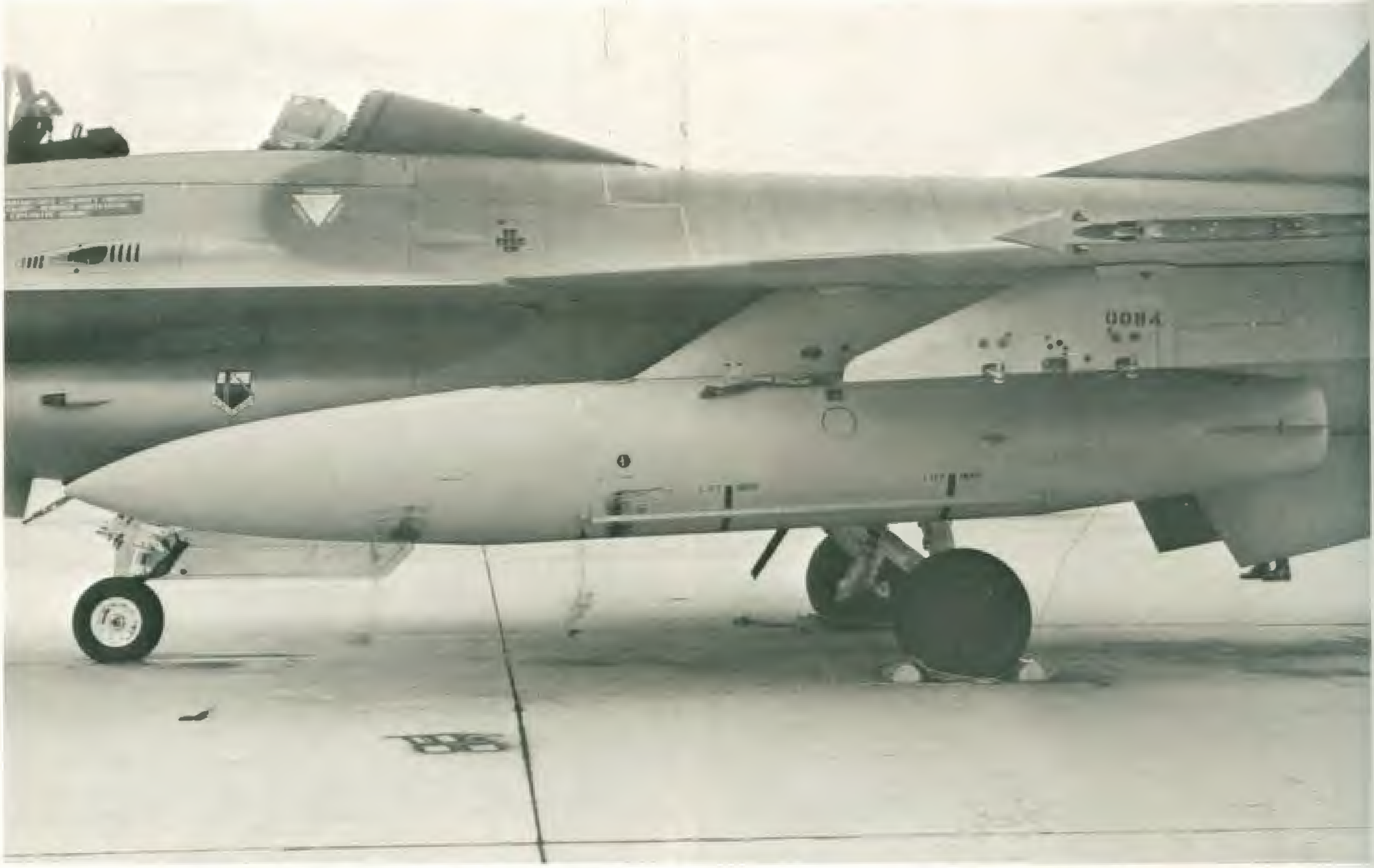
Pratt & Whitney F100-PW-200 exhaust nozzle details. Aerofax



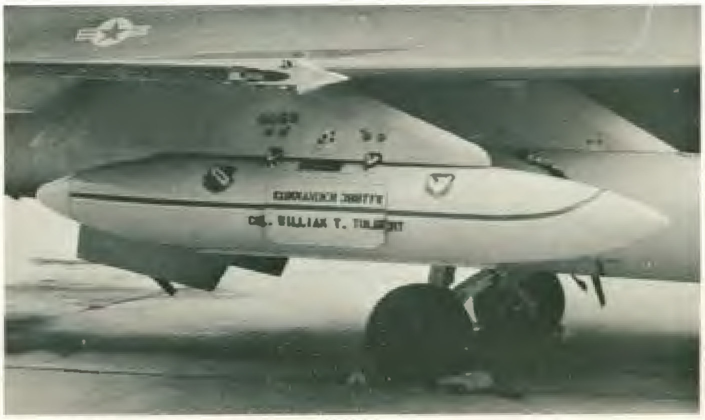
Detail of M61A-1 gun port and "Fighting Falcon" crest made official by name choice on July 21, 1980. Aerofax



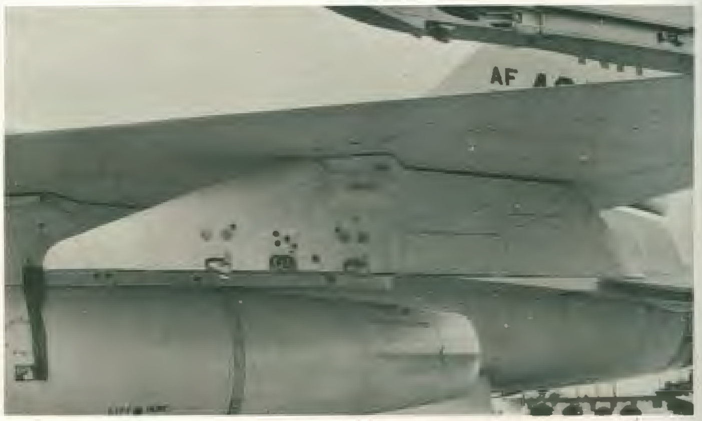
Front and rear views of standard 370 gallon external wing tanks. Tanks are usually carried on inboard wing pylons. Aerofax



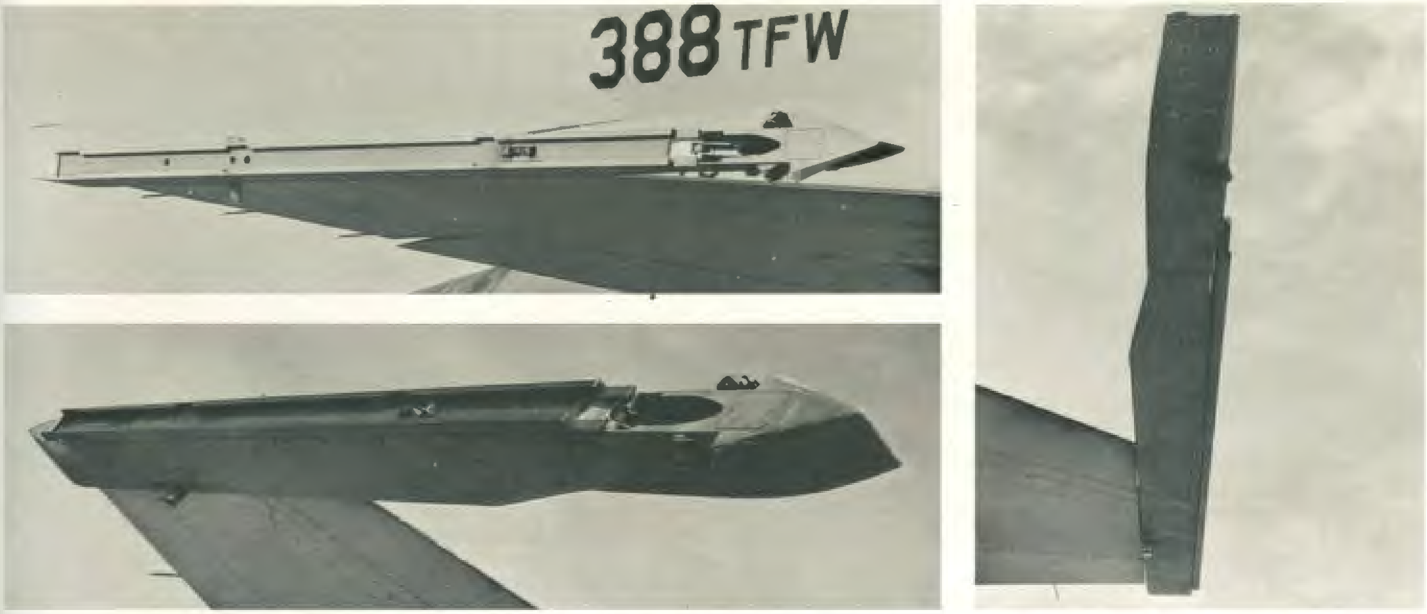
Side view of standard 370 gallon external wing tank. Note slight difference in wing pylon designs. Aerofax



Personnel packs can be carried on any of the F-16's external mounts. Commander of the 388th TFW was flying 78-0092 with specially painted pack. Aerofax



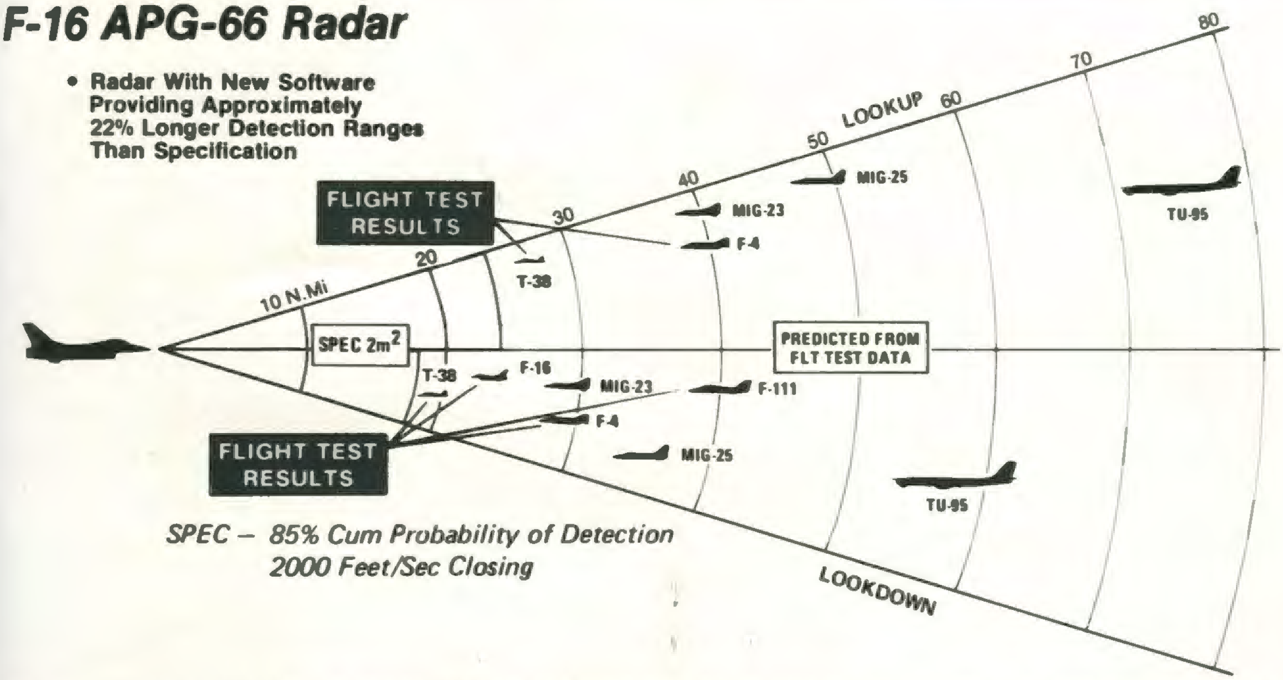
Detail of wing pylon shows bolt-on design and connectors for fuel and weapons. Aerofax



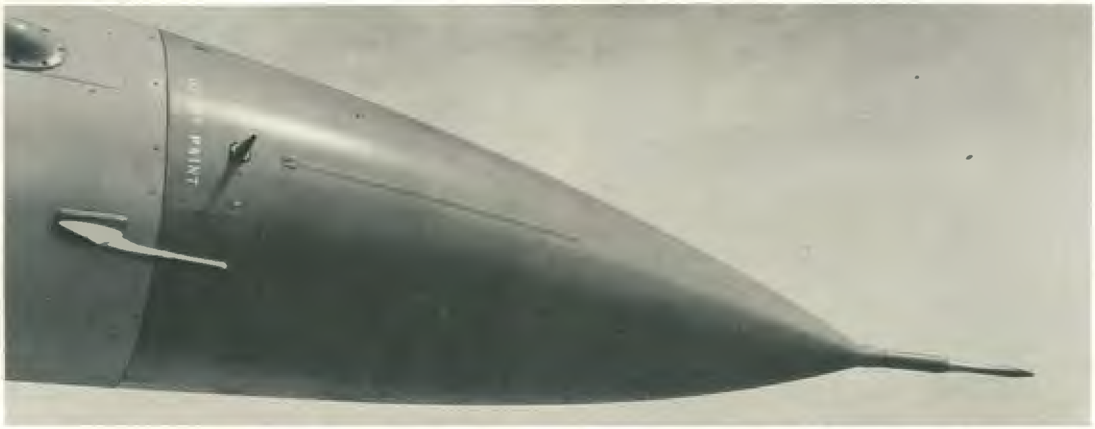
*Three views of wingtip mounted missile launch rail. Rails can be removed but F-16's are rarely flown without them. Aerofax*

## F-16 APG-66 Radar

- **Radar With New Software Providing Approximately 22% Longer Detection Ranges Than Specification**

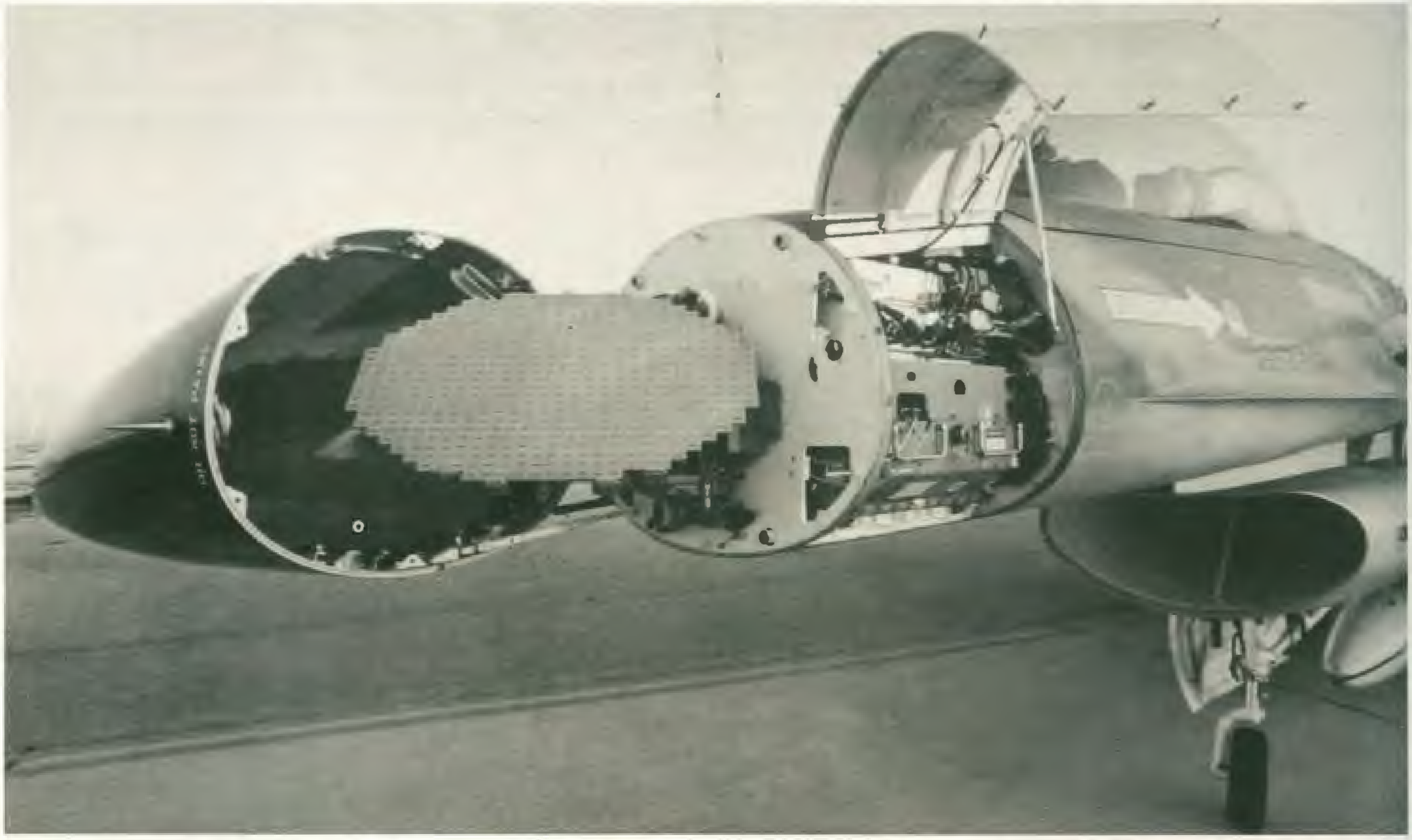


*Range capabilities of F-16's Westinghouse APG-66 radar. Contrary to implications of this drawing, flight test results are also available for MIG-21, MIG-23, and Tu-95. General Dynamics*

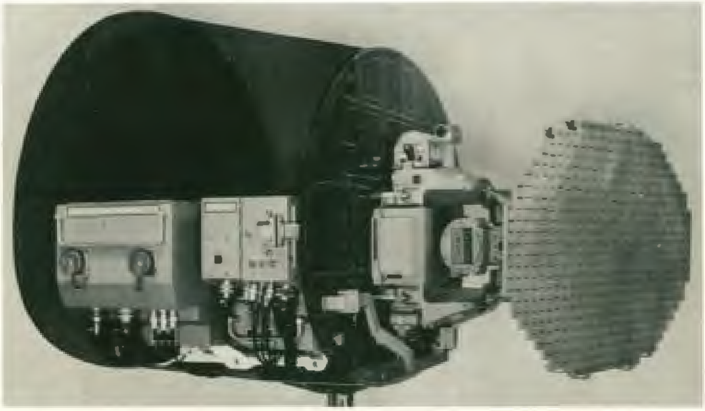


*Nose radome detail shows location of angle of attack probe and pitot sensors. Aerofax*

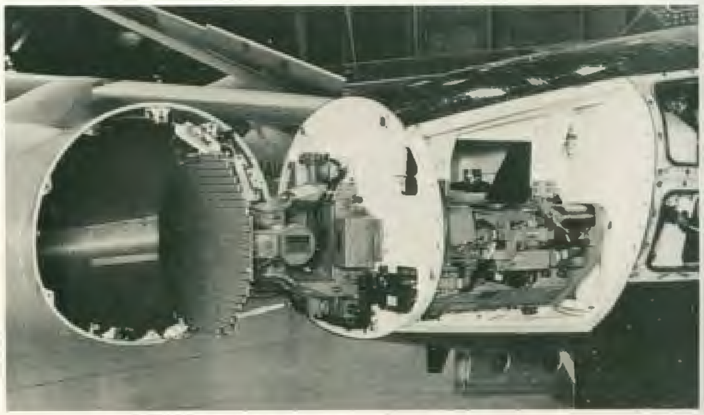
*Improved APG-66 radar is currently being tested aboard Westinghouse operated Rockwell International Sabreliner, N-903KB. Entire system includes programmable signal processor and a dual mode transmitter. First production system is scheduled for AF delivery in 1984. Sabreliner program is due for completion in May of 1982. Westinghouse*



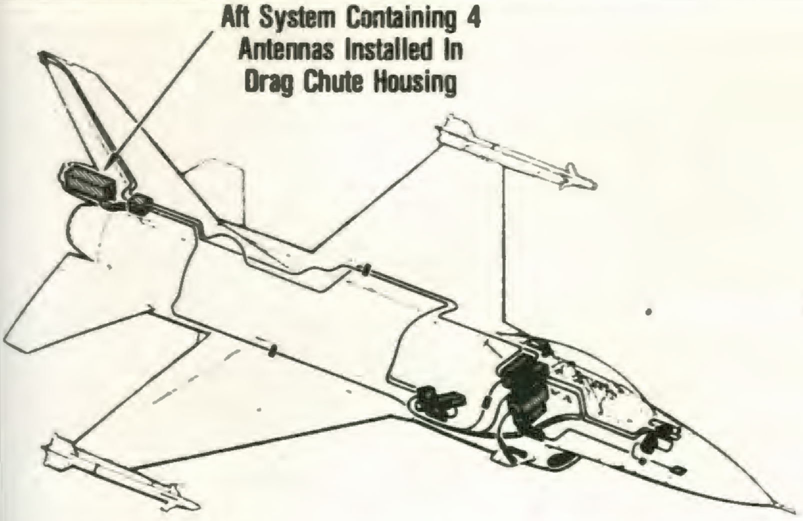
*FSD F-16A, 75-0747, was the first to be fully equipped with full avionics suit. APG-66 radar has phased array antenna unit. Westinghouse*



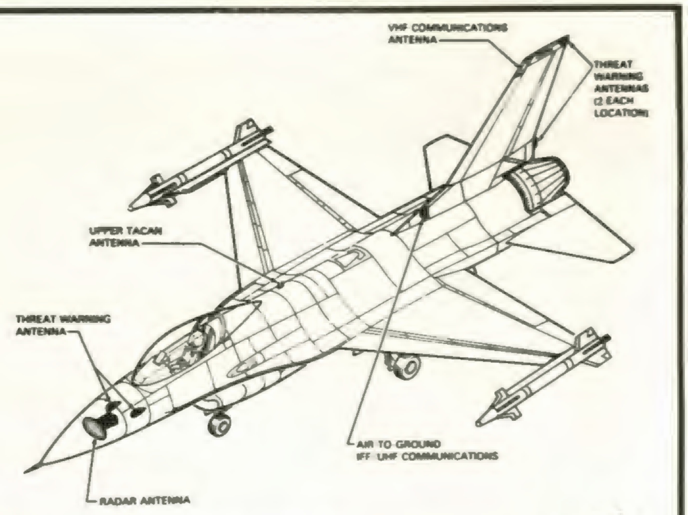
*Full-scale hardware mock-up of improved APG-66 radar for F-16. Westinghouse*



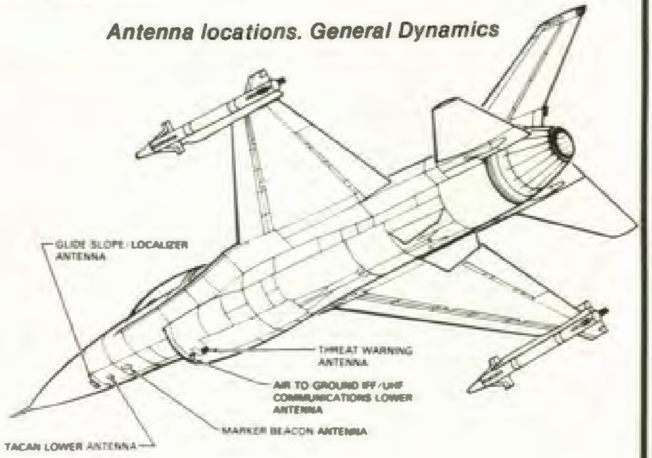
*Detail of improved APG-66 radar system as installed in Rockwell International Sabreliner by Westinghouse for flight tests. Westinghouse*

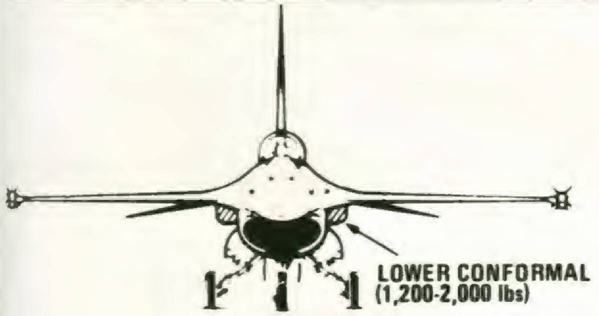

Aft System Containing 4 Antennas Installed In Drag Chute Housing

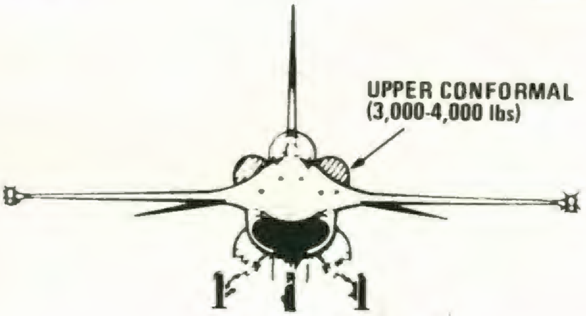
*Belgian Rapport III internal electronic countermeasures system has been tested in several F-16's at Eglin AFB, Florida with marginal results. Problems uncovered during the Eglin tests has placed the program in jeopardy. General Dynamics*

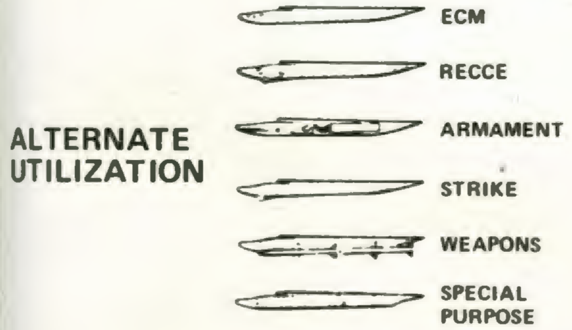

VHF COMMUNICATIONS ANTENNA
THREAT WARNING ANTENNAS (2 EACH LOCATION)
UPPER TACAN ANTENNA
THREAT WARNING ANTENNA
AIR TO GROUND IFF UHF COMMUNICATIONS
RADAR ANTENNA

*Antenna locations. General Dynamics*

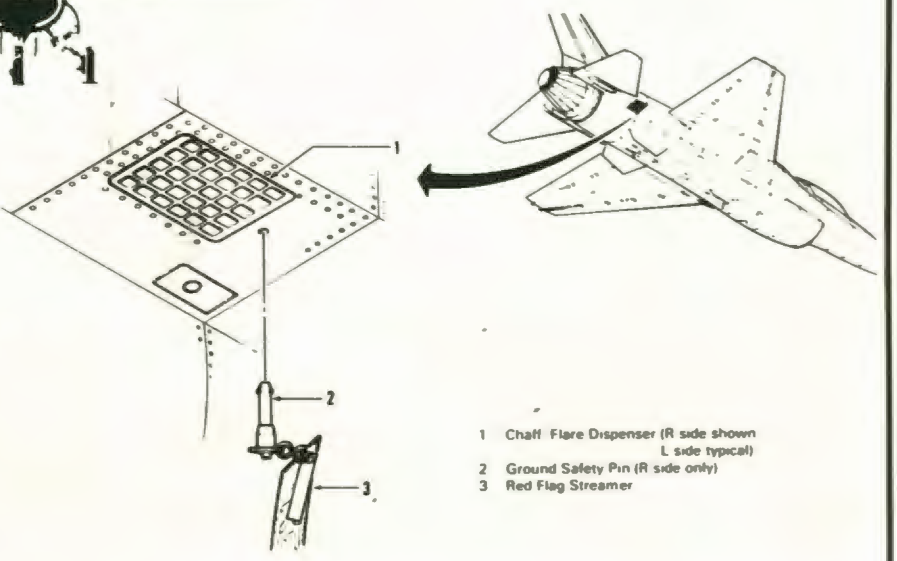

GLIDE SLOPE/LOCALIZER ANTENNA
THREAT WARNING ANTENNA
AIR TO GROUND IFF/UHF COMMUNICATIONS LOWER ANTENNA
MARKER BEACON ANTENNA
TACAN LOWER ANTENNA



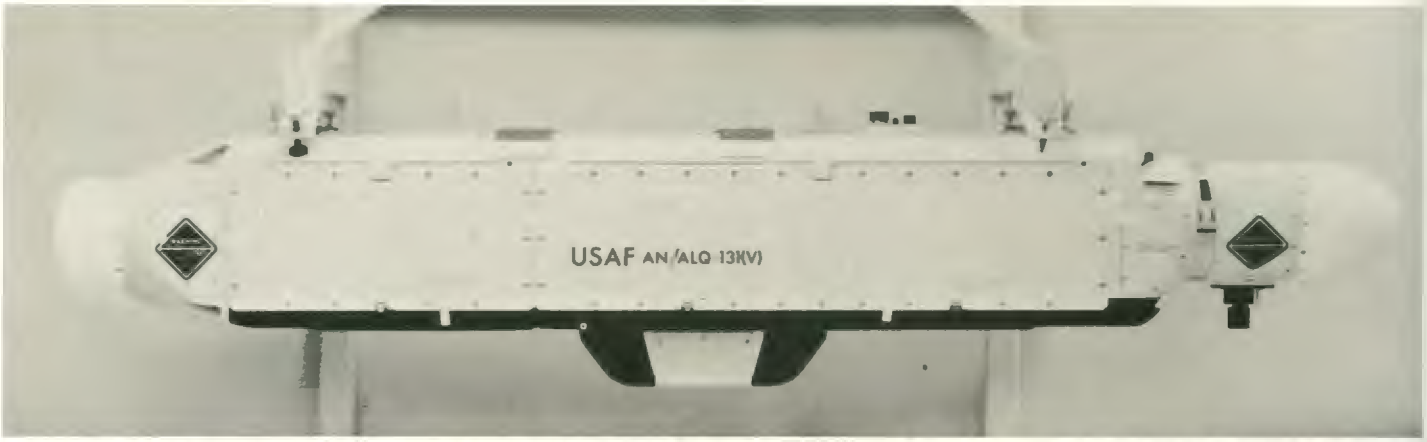




*In order to improve the F-16's already exceptional range and payload carrying ability, General Dynamics has explored the possibility of conformal fuel tank and weapons carriage. General Dynamics*


1
2
3
1 Chaff Flare Dispenser (R side shown L side typical)
2 Ground Safety Pin (R side only)
3 Red Flag Streamer

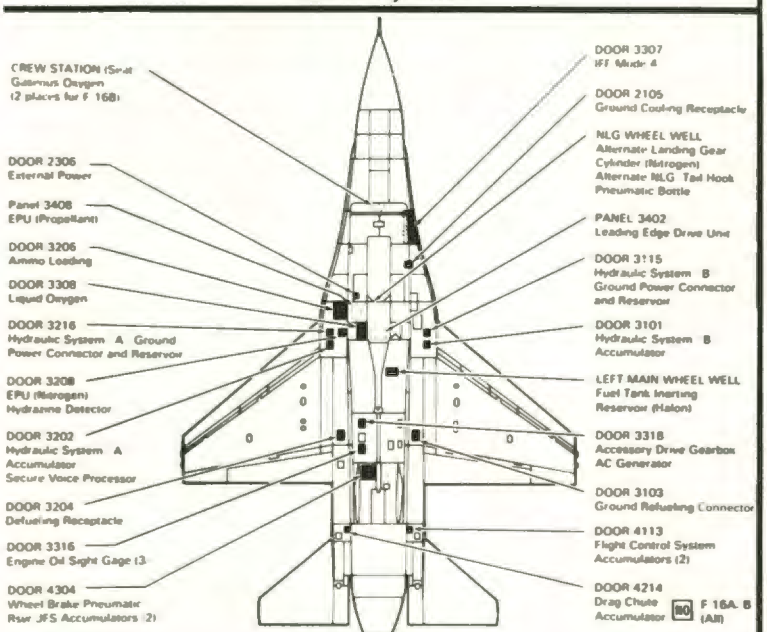
*Tracor manufactured chaff dispenser is located underneath fuselage side fairing just ahead of horizontal stabilizer leading edge. General Dynamics/USAF*



F-16 is capable of carrying several different kinds of ECM pods including the modular AN/ALQ-131. Dutch have also ordered this pod for use on their F-16's. Westinghouse

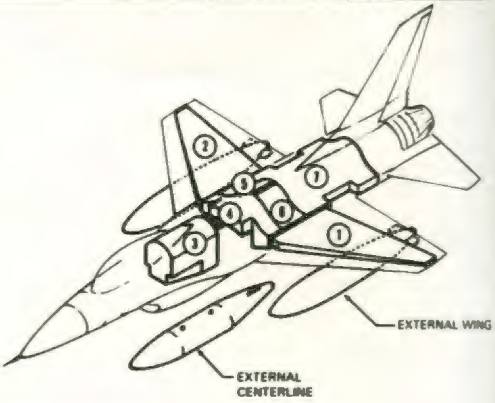
AN/ALQ-119V is shown mounted on centerline pylon. This is also a modular system ECM pod with broad frequency range capability. General Dynamics

Early test AN/ALQ-131 is shown mounted under wing of early FSD F-16A. Westinghouse


CREW STATION (Seat Gaseous Oxygen (2 places for F 16B)
DOOR 2306 External Power
Panel 3408 EPU (Propellant)
DOOR 3206 Ammo Loading
DOOR 3308 Liquid Oxygen
DOOR 3216 Hydraulic System A Ground Power Connector and Reservoir
DOOR 3208 EPU (Nitrogen) Hydrazine Detector
DOOR 3202 Hydraulic System A Accumulator Secure Voice Processor
DOOR 3204 Defueling Receptacle
DOOR 3316 Engine Oil Sight Gage (3
DOOR 4304 Wheel Brake Pneumatic Rsvr JFS Accumulators (2)
DOOR 3307 IFF Mode 4
DOOR 2105 Ground Cooling Receptacle
NLG WHEEL WELL Alternate Landing Gear Cylinder (Nitrogen) Alternate NLG Tail Hook Pneumatic Bottle
PANEL 3402 Leading Edge Drive Unit
DOOR 3115 Hydraulic System B Ground Power Connector and Reservoir
DOOR 3101 Hydraulic System B Accumulator
LEFT MAIN WHEEL WELL Fuel Tank Inerting Reservoir (Halon)
DOOR 3318 Accessory Drive Gearbox AC Generator
DOOR 3103 Ground Refueling Connector
DOOR 4113 Flight Control System Accumulators (2)
DOOR 4214 Drag Chute Accumulator
F 16A, B (All)

| SPECIFICATIONS | | USAF | NATO |
|---|---|---|---|
| FUEL | PRIMARY | MIL T 5624 JP 4 | F 40 |
| OIL | TURBINE ENGINE ACCESSORY DRIVE GEARBOX | MIL L 7808 | 0-148 |
| HYDRAULIC FLUID | | MIL H 5606 | H 515 |
| OXYGEN | LIQUID | MIL O 27210 TYPE II | NONE |
| | GASEOUS | MIL O 27210 TYPE I | |
| EXTERNAL ELECTRICAL POWER | 115 ± 15 VAC 400 + 30 Hz | A M 32A 60A | NONE |
| NITROGEN | GASEOUS | BB N 411a TYPE I GRADE B | NONE |
| FUEL TANK INERTING AGENT | LIQUID | HALON 1301 | NONE |
| MONOPROPELLANT (EPU) | LIQUID | HYDRAZINE (N2H4) (70 30%) | NONE |

Drawing illustrates various inspection doors and panels, and table lists fuels, oils, gases and miscellaneous items required for operation. General Dynamics/Air Force



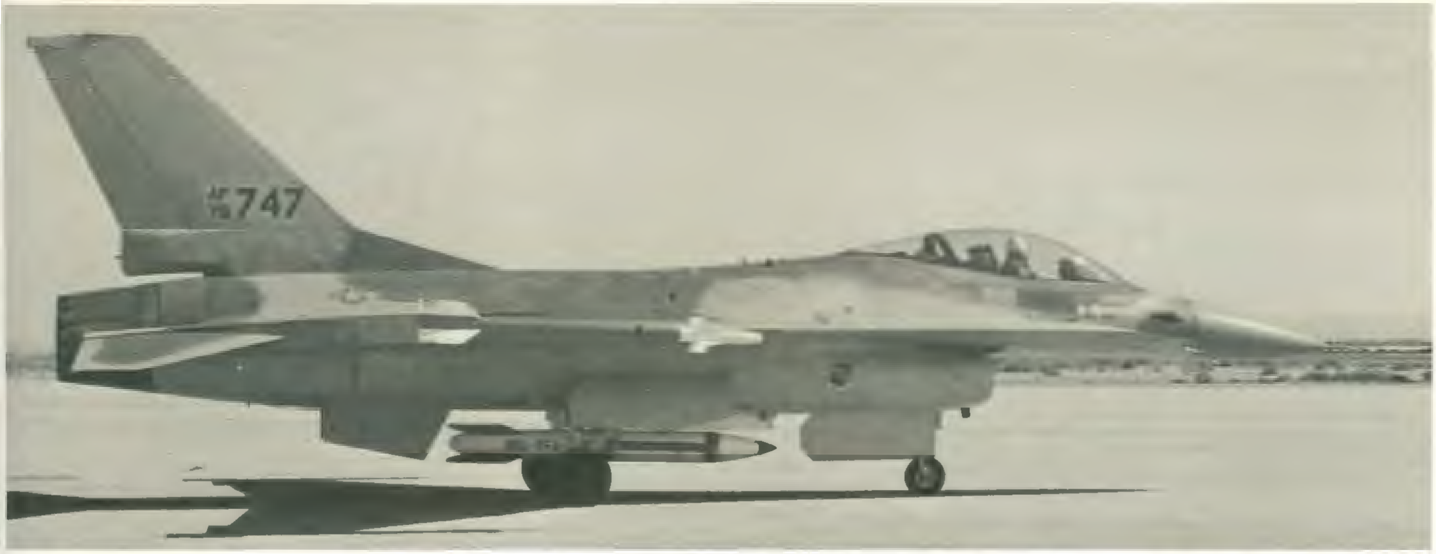
| LOCATION | F-16A | | F-16B | |
|---|---|---|---|---|
| | USABLE FUEL | | USABLE FUEL | |
| | GALLONS | POUNDS | GALLONS | POUNDS |
| ① LEFT WING INTERNAL TANK | 87.9 | 571.5 | 87.9 | 571.5 |
| ② RIGHT WING INTERNAL TANK | 87.9 | 571.5 | 87.9 | 571.5 |
| ③ F1 FUSELAGE TANK | 296.5 | 1927 | 113.8 | 740 |
| ④ F2 FUSELAGE TANK | 105.2 | 684 | 105.2 | 684 |
| ⑤ FWD RESERVOIR FUSELAGE TANK | 68 | 442 | 68 | 442 |
| ⑥ AFT RESERVOIR FUSELAGE TANK | 68 | 442 | 68 | 442 |
| ⑦ A1 FUSELAGE TANK | 355.7 | 2312 | 355.7 | 2312 |
| FUEL LINES ENGINE FEED | 3.3 | 22 | 3.3 | 22 |
| • TOTAL | 1072.5 | 6972 | 889.8 | 5785 |

NOTES
1 These figures are estimates and the weights are based on JP 4 fuel at 6.5 pounds per gallon (Std Day Only)

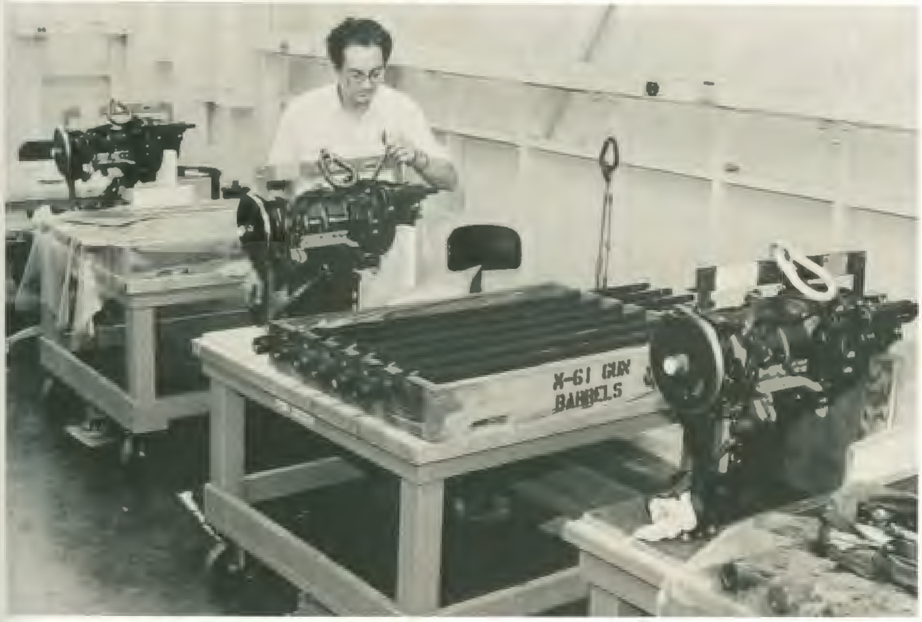
| EXTERNAL TANKS | USABLE FUEL | |
|---|---|---|
| | GALLONS | POUNDS |
| CENTERLINE | 300 | 1950 |
| WING | 740* | 4810 |
| TOTAL EXTERNAL TANK CAPACITY | 1040 | 6760 |

* TWO 370 GALLON TANKS

Fuel tank and quantity chart. General Dynamics/USAF



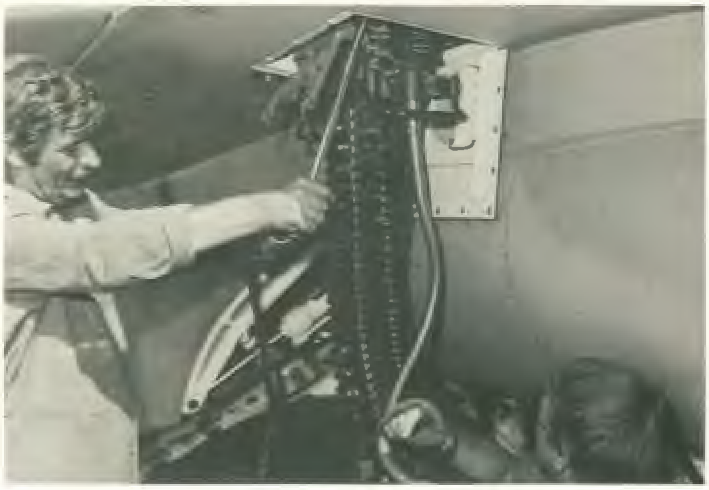
*F-16 is equipped to carry at least three types of nuclear weapons including variable yield B61, shown mounted on centerline pylon. B61 is rated at approximately 425 kilotons. General Dynamics*



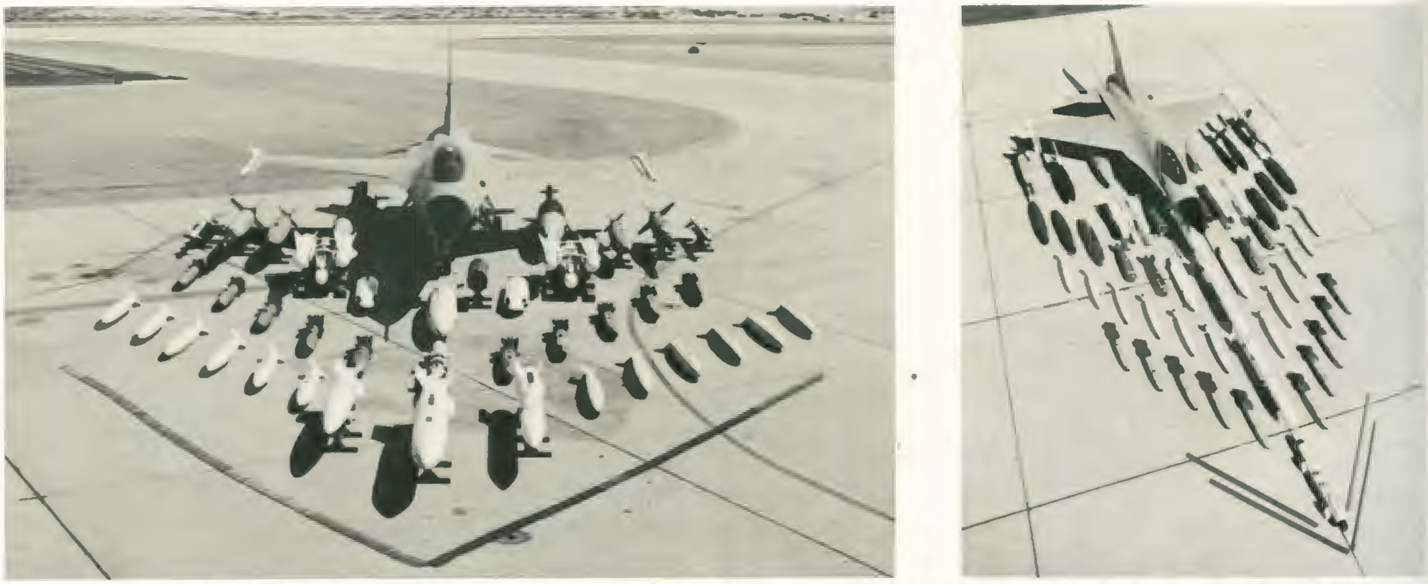
*General Electric M61A-1 rotary guns are shown prior to assembly and installation at General Dynamics. General Dynamics*

*Ammunition drum, capable of holding just over 500 20mm rounds, is lowered into position in gun bay of F-16A. General Dynamics*

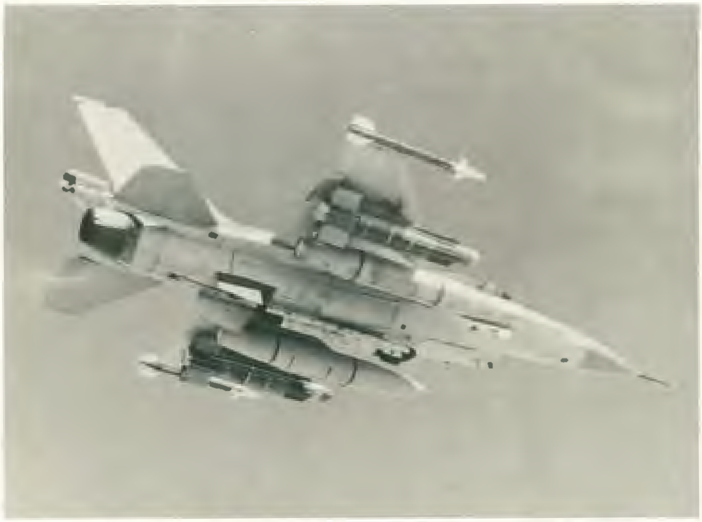
*Covered in order to keep it protected from the elements, cartridge loader for F-16 is seen just after being attached to access bay. General Dynamics*



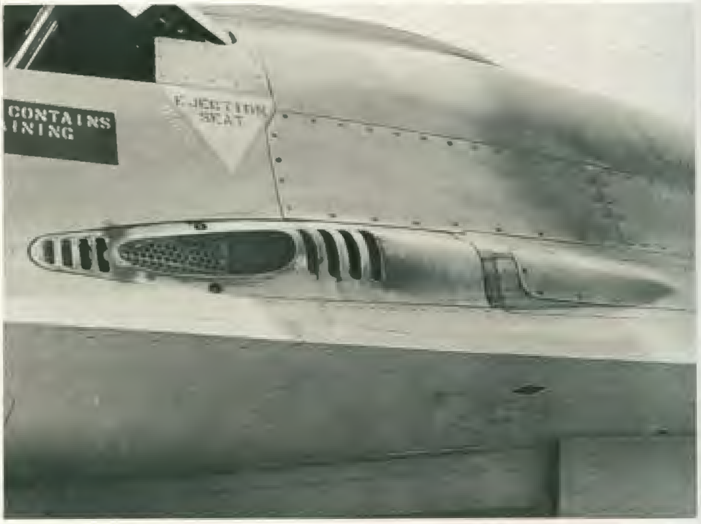
*Ammunition for M61A-1 is loaded through access panel on right side of F-16. Cartridges are elevated using electric drive unit (flexible silver tubing). General Dynamics*



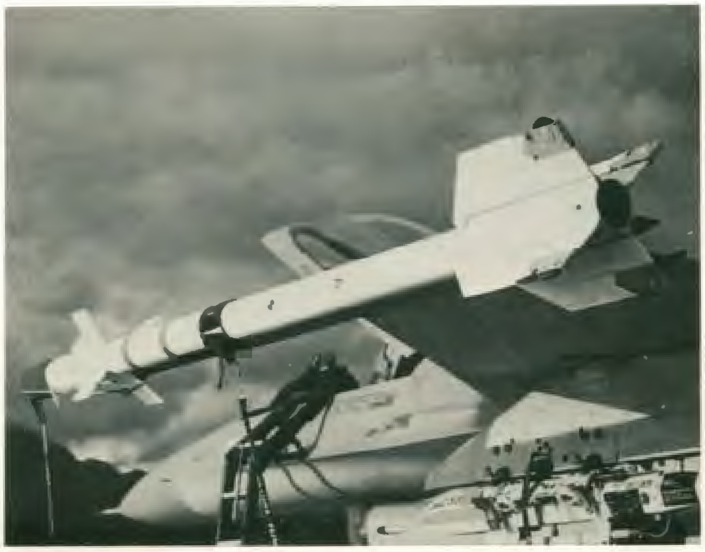
*F-16 is capable of carrying wide variety of weapons and external payloads. Weapons illustrated are detailed on p.123. General Dynamics*



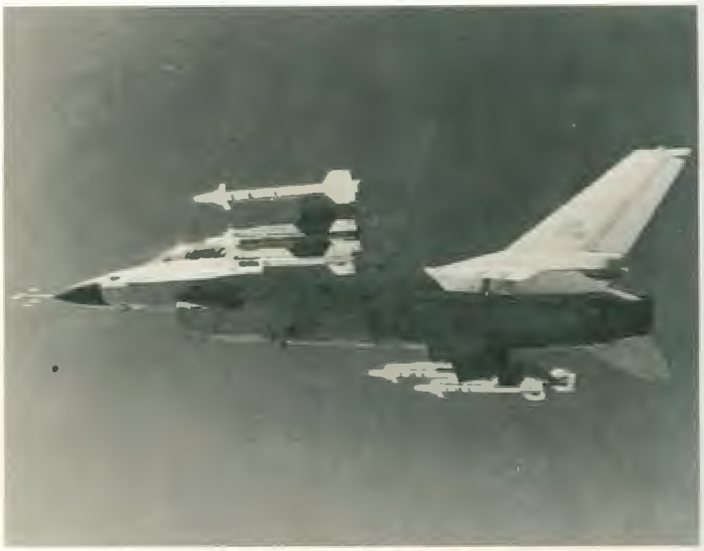
*GBU-10 is laser guided bomb unit. Two, along with a centerline mounted AN/ALQ-119 ECM pod, are seen hung from FSD F-16B, 75-0751, outer wing pylons. General Dynamics*



*Detail of gun port for M61A-1 rotary cannon. Aerofax*



*Only air-to-air missile type currently cleared for use on the F-16 is the AIM-9 Sidewinder. AIM-9L, with improved lock-on and tracking capability, is shown. General Dynamics*



*F-16 is capable of carrying as many as six AIM-9's. General Dynamics*

# APPENDIX I
## ABBREVIATED CHRONOLOGY

The following is a very brief chronology summarizing events not covered in the main text:

*May 1975—The first transAtlantic flight is completed by a YF-16.*

*August 1975—F-16A manufacturing begins.*

*December 1975—Assembly of the #1 airplane begins.*

*July 1976—The first European co-production agreement is signed.*

*January 1977—The Air Force places an order for an additional 738 F-16's.*

*October 1977—The Department of Defense endorses full scale F-16 production.*

*February 1978—The Sonaca production line in Belgium opens.*

*April 1978—The Fokker production line in the Netherlands opens.*

*July 1978—Assemblers attach first major European produced F-16 components (wings from Belgium) to Air Force F-16.*

*August 1978—The ATLIS pod is successfully tested on a YF-16 making it the first single-seat fighter to achieve accurate, unassisted delivery of laser-guided weapons.*

*May 1979—The first Dutch built F-16 flies.*

*March 1980—The Dutch F-16 order is increased from 102 to 213.*

*July 1980—The name "Fighting Falcon" for the F-16 is made official.*

*August 1980—The F-16 appears at the Farnborough Air Show for the first time.*

*September 1980—An F-16 reaches 40,000 feet altitude and Mach 2 in 6 minutes from brake release.*

*November 1980—F-16 Initial Operational Capability achieved.*

*December 1980—The 300th F-16 is delivered to the Air Force.*

*January 1981—The F-16/79 completes its development test program.*

*February 1981—A McDonnell Douglas KC-10A refuels an F-16 for the first time.*

*February 1981—The F-16 launches an AMRAAM air-to-air missile for the first time.*

*March 1981—The 100th European F-16 is delivered to the Royal Netherlands Air Force.*

*June 1981—The F-16 makes its fourth Paris Air Show appearance.*

*June 1981—F-16's win the Royal Air Force Tactical Bombing Competition at Lossiemouth, Scotland.*

*August 1981—An F-16 destroys a Convair PQM-102A drone during AMRAAM air-to-air missile tests.*

*August 1981—The 500th world-wide production F-16 is delivered.*

*November 1981—The F-16 fleet logs its 100,000th hour of flying time.*

*December 1981—Pakistan becomes the 9th country to order the F-16.*

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# APPENDIX II
## F-16 COSTS

A "designed to cost goal" of $4.55 million per aircraft in 1975 dollars was established for the first U.S. purchase of 650 F-16A's and F-16B's. General Dynamics successfully operated within the constraints of this budget and the program became one of the few in recent years to not go over cost.

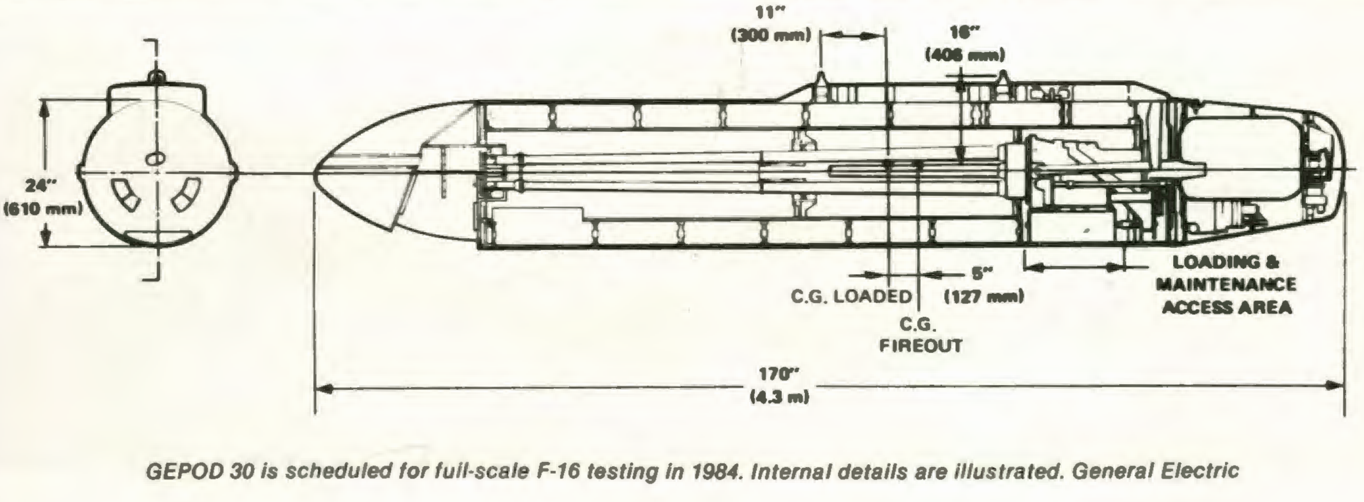
The mid-1981 unit cost of the F-16, due to inflation and other influences, is now approaching $15 million. Some economists feel that this figure, in realistic terms, is comparable to the original 1975 figure if inflation and miscellany are taken into account. Part of the reason for this cost consistency lies in the fact that the Air Force and General Dynamics pursued technical modernization efforts that trimmed some $220-million off the original budget with another $150-million in savings being envisioned.

Congress has recently approved a program wherein the Pentagon will be allowed to sign a multi-year procurement contract for future F-16's. This will mark the first time the military has been allowed to contract for a major weapons purchase beyond one year at a time. General Dynamics estimates that if the Air Force can guarantee purchase of 480 aircraft in 1982 to 1985, it can reduce the cost of the contract by $350-million (bringing total costs down to about $2.9 billion).

Historically, the F-16 is the first fighter in nearly forty years to cost less than its immediate production predecessor. To emphasize this, note the following: The North American F-86 cost 3 times the P-51 (due to its jet engine and higher speeds); the North American F-100 cost 2 times the F-86 (due to its supersonic flight capability); the McDonnell F-4 cost 2.1 times the F-100 (due to more sophisticated on-board systems); and the McDonnell Douglas F-15 cost 2.8 times the F-4 (due to further system sophistication and a Mach 2.5 speed requirement). The F-15, as point of interest, costs over twice as much as the F-16.

The following list includes the first six major contract numbers allocated for F-16 procurement:

1. GD/FWD-Contr F33657-75-C-0310; 13 Jan 75; Fixed Price Incentive Firm; Definitized (Development)
2. GD/FWD-Contr F33657-75-C-0310 (P00459); 26 Jul 78; Option 3; FPIF; Definitized (Procurement)
3. GD/FWD-Contr F33657-75-C-0310 (P00541); 3 Nov 78; Option 5; FPIF; Definitized (Procurement)
4. Pratt & Whitney-Contr F33657-75-C-0377 (P00050); 30 Dec 77; FPIF; Definitized (Procurement)
5. Pratt & Whitney-Contr F33657-75-C-0377 (P00076); 14 Nov 78; FPIF: Definitized (Procurement)
6. Singer-Link-Contr F33657-77-C-0565; 11 Nov 77; FPIF; Definitized (Procurement)



*GEPOD 30 is scheduled for full-scale F-16 testing in 1984. Internal details are illustrated. General Electric*

# APPENDIX III

## MAJOR U.S. AND EUROPEAN SUPPLIERS FOR THE F-16 PROGRAM

### Major U.S. Suppliers

| Item | Company | Location |
|---|---|---|
| Engine | Pratt & Whitney | Hartford, Connecticut |
| Hydraulic Pumps | Abex | Oxnard, California |
| Wheels, Brakes & Anti-skid | Goodyear Aerospace | Akron, Ohio |
| Inertial Navigation Set | Singer-Kearfott | Little Falls, New Jersey |
| Integrated Servo Actuators | National Water Lift | Kalamazoo, Michigan |
| Ejection Seat | McDonnell Douglas | Long Beach, California |
| 40 KVA Generator GCUs & Current Transformers | Westinghouse Electric | Lima, Ohio |
| Channel Frequency Indicator | Magnavox | Fort Wayne, Indiana |
| Main & Nose Landing Gear | Menásco | Fort Worth, Texas |
| Fire Control Computer | Delco | Goleta, California |
| Head-up Display | Marconi-Elliott | Chamblee, Georgia<br>Rochester, Kent, England |
| Fuel Pumps | TRW | Cleveland, Ohio |
| Leading Edge Flap Drive System | AiResearch | Torrance, California |
| Main Landing Gear Tires | B. F. Goodrich | Akron, Ohio |
| Nose Radome | Brunswick | Marion, Virginia |
| Engine Starting System Constant Speed Drive | Sundstrand | Rockford, Illionis |
| Canopy Transparencies | Goodyear/Sierracin | Sylmar, CA.<br>Akron, Ohio |
| Ammo Handling System | General Electric | Burlington, Vermont |
| Fuel Quantity Measuring System | Simmonds Precision | Vergennes, Vermont |
| Central Air Data Computer | Sperry Rand | Phoenix, Arizona |
| Emergency Power Unit Leading Edge Flap Drive | AiResearch | Torrance, California |
| Flight Control Computer | Lear-Siegler | Santa Monica, California |
| 5 KVA Generator | Lear-Siegler | Maple Heights, Ohio |
| A/G—IFF | Teledyne | Newbury Park, California |
| Interference Blanker | Novatronics | Pompano Beach, Florida |
| Inverter | Aerospace Avionics | Bohemia, New York |
| Stores Control Panel Face Module | Wagner | Parsippany, New Jersey |
| Rate Gyros | Northrop | Norwood, Massachusetts |
| Accelerometers | Systron-Donner | Concord, California |
| Speed Brake Door Actuator | Arkwin Industries | Westbury, New York |
| Fuel Quantity Measuring System | Simmonds Precision | Caldwell, New Jersey |
| 28 Volt Converter | Wagner Electric | Livingston, New Jersey |
| Fuel Flow Proportioner | J. C. Carter | Costa Mesa, California |
| Hydraulic Reservoirs | Parker-Hannifin | Irvine, California |
| Radar Electro-optical Display | Kaiser | Palo Alto, California |
| Cabin Temp. Sensor Fan | Hamilton Avent Electronics | Dallas, Texas |
| Turbine Compressor | Hamilton Standard | Windsor Locks, Connecticut |
| Heat Exchangers | Hamilton Standard | Windsor Locks, Connecticut |
| Chaff & Flare Dispenser | Tracor | Austin, Texas |
| Instrument Landing System | Collins | Cedar Rapids, Iowa |
| Manual Trim Panel Canopy Actuators | Talley | Newbury Park, California |
| Hydraulic Accumulator | Parker-Hannifin | Irvine, California |
| Batteries | Marathon Battery | Waco, Texas |
| Fire Control Radar | Westinghouse | Baltimore, Maryland |
| Fuel/Oil Heat Exchanger | Janitrol | Columbus, Ohio |
|  | Hughes-Treitler | Garden City, New York |
|  | United Aircraft Products | Dayton, Ohio |
| Oxygen Regulator | Robertshaw | Anaheim, California |
| Ammo Loading System | General Electric | Burlington, Vermont |
| Avionics Intermediate Shop | General Dynamics/Electronics | San Diego, California |
| Fuel Tanks | Sargent-Fletcher | El Monte, California |
| Pneumatic Sensor, Ice Detector | Rosemount | Minneapolis, Minnesota |
| Aluminum | Alcoa | Davenport, Iowa |
|  | Kaiser | Trentwood, Washington |
|  | Ducommun | Dallas, Texas |
|  | Reynolds Metals | McCook, Illinois |
| Steel | Earle M. Jorgenson | Dallas, Texas |
|  | Republic Steel | Cleveland, Ohio |
|  | Latrobe | Latrobe, Pennsylvania |
|  | Carpenter Technology | Dallas, Texas |
| Wire | Tensolite | Buchanan, New York |
| Titanium | Titanium Metals Corp. | Toronto, Ohio |
|  | RMI Corp. | Niles, Ohio |
| Simulated Aircraft Maintenance Trainer (SAMT) | Honeywell | West Covina, California |
| Microwave Test Stations | Hewlett-Packard | Cupertino, California |
| Depot Analog Test Stations | Honeywell | St. Louis Park, Minnesota |
| Depot Digital Test Stations | Texas Instruments | Dallas, Texas |

### Major European Suppliers

| Item | Company | Location |
|---|---|---|
| Radar Computer | MBLE | Brussels, Belgium |
| Airframe | SONACA | Gosselies, Belgium |
| Airframe, Integrated Servo Actuator | SABCA | Brussels, Belgium |
| Engine Fan & Core & Assembly | Fabrique Nationale | Herstal, Belgium |
| Pneumatic Sensor, Flight Control Computer; Radar Control Panel; Ice Detector | Burmeister & Wain | Lystrup, Denmark |
| Airframe | Per Udsen | Grenaa, Denmark |
| Engine Gear Box, Chaff & Flare Dispenser, EPU Controller, ESS Controller | DISA | Herlev, Denmark |
| Flight Control Components, Avionics Intermediate Shop | Standard Electric | Horsens, Denmark |
| Leading Edge Flap Drive | Jorgen Hoyer | Vekso, Denmark |
| Heat Exchangers | Quitzau | Sonderborg, Denmark |
| Radar Electro-optical Display | Nea-Lindberg | Ballerup, Denmark |
| Fire Control Computer | Christian Rovsing & NESELCO | Herlev, Denmark |
| Channel Frequency Indicator, 40 KVA Generator | Radartronic | Risskov, Denmark |
| Inverter | Silcon | Kolding, Denmark |
| Ammo Handling System | Raufoss | Raufoss, Norway |
|  | Norcem Plast | Drammen, Norway |
|  | Sperry-Vickers | Ski, Norway |
| HUD EU & Rate Gyros, Brakes, Anti-skid, Inertial Nav Set, Stores Management Set, Turbine Compressor, Rate Gyros, |  |  |
| Engine Fan Drive | Kongsberg | Kongsberg, Norway |
| Interference Blanker | Gustav A. Ring | Oslo, Norway |
| Radar Racks | NERA | Bergen, Norway |
| AG/IFF | Standard Telefon | Oslo, Norway |
| Constant Speed Drive Main Wheels | Raufoss | Raufoss, Norway |
| Airframe | Fokker | Amsterdam, The Netherlands |
| Landing Gear | DAF | Eindhoven, The Netherlands |
| Radar Antenna, Threat Warning Sys. | Signaal | Hengelo, The Netherlands |
| HUD Pilot Display Unit | Oldelft | Delft, The Netherlands |
| 370 Gallon External Fuel Tanks | Nordisk | Holmstrand, Norway |
| Ride Quality Study | National Aerospace Laboratory | Amsterdam, The Netherlands |
| Fuel Quality Measuring System | Simmonds | Brummen, The Netherlands |
| Engine Afterburner | Philips | Eindhoven, The Netherlands |

*Number two prototype YF-16 tested type's ability to carry and launch AIM-7 Sparrow. Main landing gear door mounting of missile was unusual, but functional. General Dynamics*

# APPENDIX IV
# REFERENCES

## Books

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- JANE'S ALL THE WORLD'S AIRCRAFT, 1975/76 edition, edited by John W. R. Taylor, Jane's Yearbooks, 1975, 830p.
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- THE OBSERVER'S SOVIET AIRCRAFT DIRECTORY, William Green and Gordon Swanborough, Frederick Warne (Publisher's) Ltd., London, England, 1975, 256p.
- AIRCRAFT, ENGINES, AND AIRMEN, August Hanniball, The Scarecrow Press, Inc., Metuchen, New Jersey, 1972, 825p.
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- GRUMMAN F-14 TOMCAT, James P. Stevenson, Aero Publishers, Inc., Fallbrook, California, 1975, 104p.
- MCDONNELL DOUGLAS F-15 EAGLE, James P. Stevenson, Aero Publishers, Inc., Fallbrook, California, 1978, 104p.
- U.S. MILITARY AIRCRAFT DESIGNATIONS AND SERIALS SINCE 1909, John Andrade, Midland Counties Publications, Leicester, England, 1979, 254p.
- THE HIGH SPEED FRONTIER, CASE HISTORIES OF FOUR NACA PROGRAMS, 1920-1950, John V. Becker, NASA, Washington, D.C., 1980, 190p.

## Miscellaneous Publications:

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- THE F-15 EAGLE, ORIGINS AND DEVELOPMENT 1964-1972, Jacob Neufeld, Office of Air Force History, 1974, 105p.
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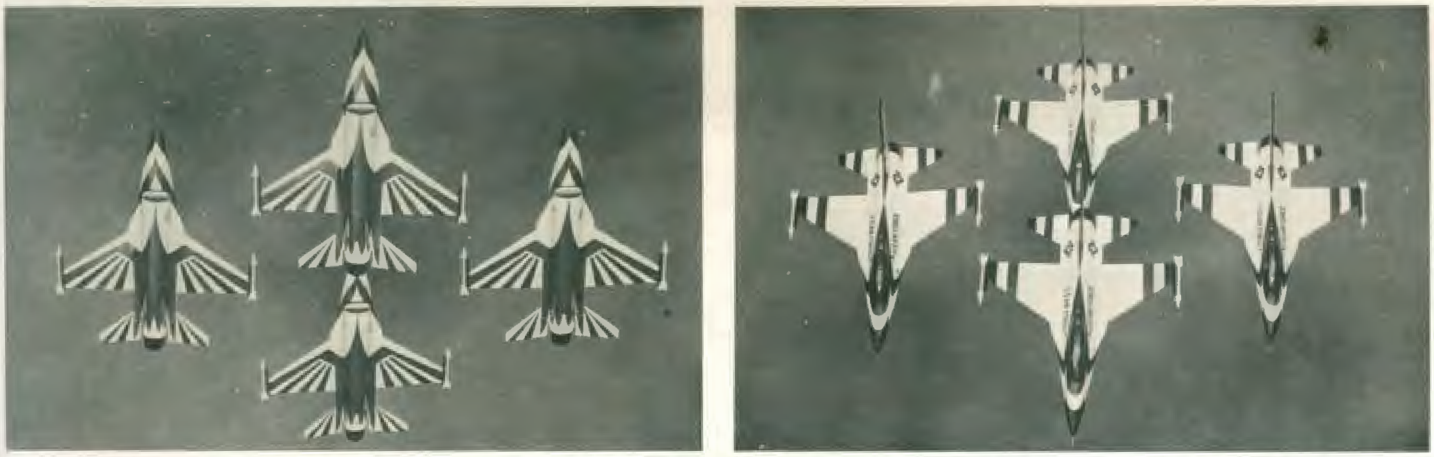
## Interviews:

Lyman Josephs III, Harry Hillaker, Phil Oestricher, Fred Bettinger, Vinko Dolson, John Boyd, Pierre Sprey, Capt. Marc Moore, Capt. John Rogers, and numerous F-16 pilots and General Dynamics personnel.

Finally, I would like to note that any corrections would be greatly appreciated. I ask only that you verify your information via a reliable source or quotable publication. I can be contacted via AEROFAX, INC., P.O. Box 5337, Austin, Texas 78763-5337. Thanks.

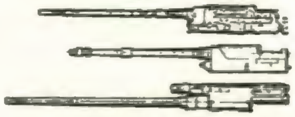
Jay Miller

*Air-to-ground capability of F-16 is enhanced by its ability to carry and launch the AGM-65 Maverick. General Dynamics*



*The USAF Thunderbirds are scheduled to transition to the F-16 from the T-38 in the fall of 1982. It is assumed they will perform in F-16's during the 1983 season. Active AF aircraft are to be pulled from the inventory to form the aerobatic team. Proposed Thunderbirds markings are shown in these illustrations of painted models. The actual scheme may vary considerably from that depicted. General Dynamics*

## ALTERNATE GUN CAPABILITY EXPANSION



MAUSER MK-27. . . . . . . . . . . . . . . . . .27mm

D.E.F.A. 553. . . . . . . . . . . . . . . . . . . .30mm

OERLIKON KCA . . . . . . . . . . . . . . . . .30mm

*The General Electric M61A-1 is not the only gun to have been considered for the F-16. These alternatives are considered optional and foreign air force orders for them are quite possible. General Dynamics*

*Stock helmet and g-suit gear worn by F-16 pilots (474th TFW pilot gear shown). Aerofax*

DATA BASIS FLIGHT TEST
DATE 22 AUGUST 1980

NOTE WEIGHT AND DRAG INDICES DO NOT INCLUDE SUSPENSION EQUIPMENT. REFER TO FIGURE A1-2.

| STORE | STATION | RACK | WEIGHT LBS (EACH STORE) | DRAG INDEX (EACH STORE) |
|---|---|---|---|---|
| AGM-65A,B | 3 OR 7 | LAU-88 | 464 | 13 |
| AIM-9J/P/N* OR ACMI | 1 OR 9 | AAM | 169 | 4** |
| AIM-9L | 1 OR 9 | LAUNCHER | 189 | 7** |
| AIM-9J/P/N* | 2 OR 8 | AAM | 169 | 7 |
| AIM-9L | 2 OR 8 | LAUNCHER | 189 | 10 |
| ALQ-119-15 (INCL. ADAPTER-PYLON) | 5 | NONE | 623 | 23 |
| ALQ-119-15 | 3 OR 7 | MAU-12C/A | 580 | 19 |
| ALQ-119-17 | 3 OR 7 | MAU-12C/A | 406 | 19 |
| PAVE PENNY POD (INCL. PYLON) | SIDE OF NACELLE | — | 80 | 2 |
| B43 (BDU-8 OR -18) | 3 OR 7 | MAU-12C/A | 2120 | 24 |
| B57 (BDU-12 OR -19) | 3, 5, OR 7 | MAU-12C/A | 510 | 9 |
| B61 (BDU-38) | 3, 5, OR 7 | MAU-12C/A | 716 | 8 |
| GBU-8/B | 3 OR 7 | MAU-12C/A | 2265 | 21 |
| GBU-10A/B, -10/B | 3 OR 7 | MAU-12C/A | 2052 | 17 |
| MK-20 MOD 4 | 3 OR 7 | BRU-31/A | 490 | 14 |
| MK-82 | 3 OR 7 | BRU-31/A | 510 | 7 |
| MK-82S | 3 OR 7 | MAU-12C/A | 550 | 6 |
| MK-82S | 3 OR 7 | BRU-31/A | 550 | 9 |
| MK-84 | 3 OR 7 | MAU-12C/A | 1970 | 11 |
| SUU-20B/A: | | | | |
| (6) BDU-33 | 3 OR 7 | MAU-12C/A | 458 | 14 |
| (6) MK-106 | 3 OR 7 | MAU-12C/A | 305 | 14 |
| EMPTY | 3 OR 7 | MAU-12C/A | 276 | 12 |
| SUU-25C/A: | | | | |
| MK-24 FLARES | 3 OR 7 | BRU-31/A | 470 | 16 |
| LUU-2/B FLARES | 3 OR 7 | BRU-31/A | 494 | 16 |
| EMPTY | 3 OR 7 | BRU-31/A | 264 | 16 |
| 370-GALLON TANK (EMPTY/FULL) | | | | |
| NO STORES AT 3 OR 7 | 4 OR 6 | NONE | 460/2855 | 23 |
| SINGLE RACKS OR STORES AT 3 OR 7 | 4 OR 6 | NONE | 450/2855 | 31 |
| MULTIPLE STORES AT 3 OR 7 | 4 OR 6 | NONE | 450/2855 | 35 |
| 300-GALLON TANK (EMPTY/FULL) | | | | |
| NO STORES AT 4 OR 6 | 5 | TANK PYLON | 525/2476 | 23 |
| STORES AT 4 & 6 | 5 | TANK PYLON | 526/2476 | 26 |

*AIM-9 missile variances in weight and drag index are virtually negligible

**Used for removing tip missile only as basic configuration includes AIM-9s at 1 and 9

*The F-16's weapon and externally mounted pod and fuel tank options generally consist of these. MSIP modifications will create significant changes to this list. General Dynamics/USAF*

## Addenda:

The following information was published in Aviation Week & Space Technology (April 26, 1982), as Aerograph I was going to press: "A wide range of modifications to update the General Dynamics F-16 fighter is being incorporated in multinational production series aircraft for Belgium, Holland, Denmark, and Norway to match an improvement program started by the USAF. General Dynamics officials based in Europe said the modernization program, called Pacer Loft, insures that improvements in software, additional weapons flexibility, flight controls, stores management, and radar systems are included in all aircraft in the five nation program. As of April, 1982, each of the four European air forces involved have at least one aircraft already incorporating the Pacer Loft changes. By March of 1984, more than 100 European F-16's will have been updated.

Pacer Loft modifications include: **(1)** Changing the paint scheme of the F-16's radome from black to camouflage grey; **(2)** Adding a data recorder to the pilot ejection seat to insure that flight system data are ejected in an accident; **(3)** Drilling drain holes in the aircraft's forward area and in the vertical fin to keep rain water from accumulating; **(4)** Installing a canopy that is interchangeable with other F-16's; **(5)** Adding a ground test panel to verify that redundant power for the flight control system is operable; **(6)** Improvements in the Westinghouse AN/APG-66 radar unit, increasing target acquisition and lock-on capability; **(7)** Integrating a new movable side control stick, replacing the previous stick; **(8)** Improving protection against static electricity; **(9)** Adding an audible warning system to alert the pilot when he is reaching the aircraft's performance limits, such as g force and altitude."

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